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May 16, 2011

ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: SAT-MOD-20101118-00239

Dear Ms. Dortch:

In its Order dated January 26, 2011 ("*LightSquared Order*"), the Federal Communications Commission ("Commission") required LightSquared Subsidiary LLC ("LightSquared") to submit reports on the 15th day of each month describing the progress of the Working Group ("WG") convened to study the GPS overload/desensitization issue discussed in the *LightSquared Order*, concluding in a Final Report due no later than June 15, 2011.[1]

A copy of the WG's third progress report ("May Progress Report"), hereby submitted to the Commission jointly by LightSquared and the United States Global Positioning System ("GPS") Industry Council ("USGIC") as Co-Chairs of the Working Group, is attached. As discussed in greater detail in the May Progress Report, the Technical Working Group is continuing the work outlined

[1] *LightSquared Subsidiary LLC; Request for Modification of its Authority for an Ancillary Terrestrial Component*, SAT-MOD-20101118-00239, DA 11-133, ¶ 43 (rel. Jan. 26, 2011).

by the initial report.[2] The sub-teams of the Technical Working Group continue to meet regularly and have been focused on finalizing test plans, laboratory set-ups, the device selection process and the live-sky testing program. As of today, testing is underway for six device categories and has been completed for the Space-Based Receivers category.

Please do not hesitate to contact me with any questions.

Respectfully,

Henry Goldberg

Henry Goldberg
Counsel for LightSquared Subsidiary LLC

cc: Julius Knapp, FCC
Mindel De La Torre, FCC
Ruth Milkman, FCC
Ron Repasi, FCC
Karl Nebbia, NTIA
Tony Russo, NTIA
Eddie Davison, NTIA
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[2] Letter from Henry Goldberg, Counsel for LightSquared Subsidiary LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, File No. SAT-MOD-20101118-00239 (Feb. 25, 2011) (attaching initial report, including work plan).

Third GPS Working Group Progress Report
May 16, 2011

Introduction

This is the third monthly progress report of the Working Group (WG) that was formed to study the GPS overload/desensitization issue as described by the Commission in DA 11-133. On February 25, 2011, LightSquared and the United States Global Positioning System Industry Council (USGIC) submitted a Work Plan to the Commission outlining the intended actions and governance of the WG to study fully the potential for overload interference/desensitization to GPS receivers, systems, and networks. Subsequent progress reports were filed with the Commission on March 15 and April 15, 2011. LightSquared, along with the non-governmental members of the GPS Technical Working Group (TWG) hereby submit this progress report which has been approved by the Co-Chairs of the WG[1].

Progress to Date

As detailed in previous reports, the WG has established several sub-teams that are comprised of members and advisors with expertise and/or interest of particular relevance to the specific device and receiver categories defined by the TWG. The current list of all WG members, including TWG members and advisors, can be found in Appendix A to this report. This list also provides updated information regarding current sub-team participants.

The sub-teams continue to meet regularly and have been focused on finalizing test plans, laboratory set-ups, the device selection process and the live-sky testing program in Las Vegas. As of May 16, testing is underway for six device categories and has been completed for the Space-Based Receivers category. In its April 15 progress report, the WG attached the then-current draft test plans and the list of devices and receiver models submitted for testing by companies. Where test plans have undergone subsequent revision, those revised plans are attached as appendices to this progress report. The current list of devices identified for testing is included as Appendix B. Test results will be published in the final report, with the identity of each tested receiver to be randomly coded within each category.

The TWG continues to meet weekly, including in person and via teleconference to monitor and review sub-team progress and to address matters of general applicability across sub-teams.

Sub-Team Specific Updates

[1] This report was prepared with technical input from USG employees and contractors but does not necessarily represent their views.

This section provides brief updates from each of the sub-teams. The June 15th final report will provide more extensive information relative to each device category including test results and work-plan elements that are test-result dependent.

Aviation Sub-Team

- Laboratory testing is scheduled to be completed by May 20 under a test plan developed by RTCA, with the participation of TWG Aviation Sub-Team members including LightSquared and conducted by Zeta Associates which was supervised by the FAA and the Aviation sub-team. Zeta is testing a total of ten devices which are listed in Appendix B.
- RTCA is in the process of compiling its results and writing up the test report; members of the aviation sub-team are actively involved in this process.
- The laboratory testing results will provide some indication of whether representative airborne GPS receivers exceed the applicable FAA and ICAO standards.
- The Aviation sub-team expects to have receivers now under testing by Zeta Associates available for field testing in Las Vegas (see below) toward the end of the two-week field-test period.
- The final Aviation laboratory test plan is attached as Appendix C.

Cellular Sub-Team

- The Cellular sub-team has engaged three independent laboratories: PCTEST, Intertek and ETS Lindgren.
- PCTEST is currently fully functional and is performing radiated testing of devices selected by the sub-team. PCTEST has recently added a second shift in order to expand its testing capacity and meet the required completion date set by the TWG.
- Intertek is also fully functional and is performing conducted testing of devices selected by the sub-team. It has also recently added a second and third shift to accommodate the TWG's testing schedule.
- ETS Lindgren is currently being configured to perform conducted testing and will be begin testing with two shifts per day on or about May 16.
- The current Cellular laboratory test plan is attached as Appendix D; the team is studying and preparing to adopt certain measures to improve the efficiency of the testing process.

General Location/Navigation Sub-Team

- The General Location/Navigation sub-team has recently added additional members representing public safety users at the request of the National Public Safety Telecommunications Council (NPSTC).
- The sub-team has completed accumulation of live-sky GPS test data for use in dynamic testing scenarios.

- Alcatel Lucent (ALU) has finalized the testing setup and [as of May 16] has begun full-scale testing according to the test plan developed by the sub-team.
- ALU is currently utilizing two anechoic chambers (located in Murray Hill, NJ and Naperville, IL), working two shifts per day. The current device testing forecast shows that tests will be complete on June 7, but the sub-team is working with ALU to determine how to move the dates forward. The sub team is working with ALU to report partial results to the TWG by May 31.
- The sub-team expects to have receivers of the same models that will be tested by ALU available for field testing in Las Vegas (see below), and is working to develop test procedures for field tests.
- The current General Location/Navigation laboratory test plan is attached as Appendix E.

High Precision Sub-Team
Networks Sub-Team
Timing Sub-Team

The High Precision, Networks and Timing sub-teams (HPN&T Sub-Teams) are collaborating extensively and have developed joint test plans and procedures. Their activities are being reported jointly for the purposes of this progress report.

- As of May 13, the sub teams have completed testing of all devices in the NAVAIR lab facility.
- Some members of the sub-team expect to have some receivers of the same models that have been tested by NAVAIR available for field testing in Las Vegas (see below), and are working to develop test procedures for the field tests.
- Members of the sub team are now processing and compiling the test results
- The final joint laboratory test plan for these sub-teams is attached as Appendix F.

Space-Based Receivers Sub-Team

- As reported in the April 15 progress report, the Space-Based Receiver sub-team has completed its laboratory testing activities and is now in the process of reviewing the initial draft analysis of the impacts of the LightSquared system on space-based and high precision science receivers using the scenarios developed earlier in the TWG. In the coming weeks, the Space-Based Receiver Sub-team will be evaluating potential mitigation measures as required under Item 11 of the Work Plan and writing its final report.

Work Plan Items 9-11

The sub teams are at various stages of evaluating the remaining items in the Work Plan:

Item 9: Analyze test results based on established methodology

Using the methodology established earlier in the work plan, analyze the results to determine the proposed terrestrial signal transmissions effect on GPS operations.

Item 10: Assess operational scenarios using analytics and test results

The TWG will analyze the test results in the context of the operational scenarios in order to assess the practical impact of receiver desensitization / overload conditions on the installed user base. This will allow for the identification of areas of concern. This task will begin after test results have been evaluated and scenarios identified and defined.

Item 11: Assess whether any mitigation measures are feasible and appropriate

The TWG will identify mitigation options, if feasible, including LightSquared design considerations, types of components, transmit power, and/or operational frequency modifications that, along with the OOBE restrictions previously agreed to between LightSquared and the USGIC, will prevent receiver desensitization/overload from occurring in installed GPS operations. Any mitigation recommendations mutually acceptable to the Co-Chairs will be provided to the Commission in LightSquared's final report which is due on June 15, 2011.

LightSquared has arranged for a filter- manufacturer presentation in two sub-teams. The subject of the feasibility of potential future filters relates to mitigation (see item 11). The feasibility and appropriateness for a user of the various mitigation proposals described in item 11 will be considered under the operational scenario for that user (examined in item 10). Mitigation will be evaluated for the feasibility to sustain current and planned user scenario performance. A variety of spectrum deployment scenarios by LightSquared are also being evaluated.

The sub teams will present their assessments of these Work Plan items to the TWG for its consideration and discussion prior to the filing of the final report on June 15.

Field Testing

As discussed in item 7 in the WG's February 25, 2011 Work Plan, the WG will perform testing of some devices and receivers in a field environment. LightSquared [as of May 16] has set up and has begun operation of four field test locations in the area in and around Las Vegas, NV. This testing is being conducted pursuant to a Special Temporary Authority issued by the Commission on May 12, 2011. The FAA has issued appropriate Notices to Airmen in the areas surrounding the test locations to alert the aviation community about any possible interruption in GPS signals within aircraft avionics.

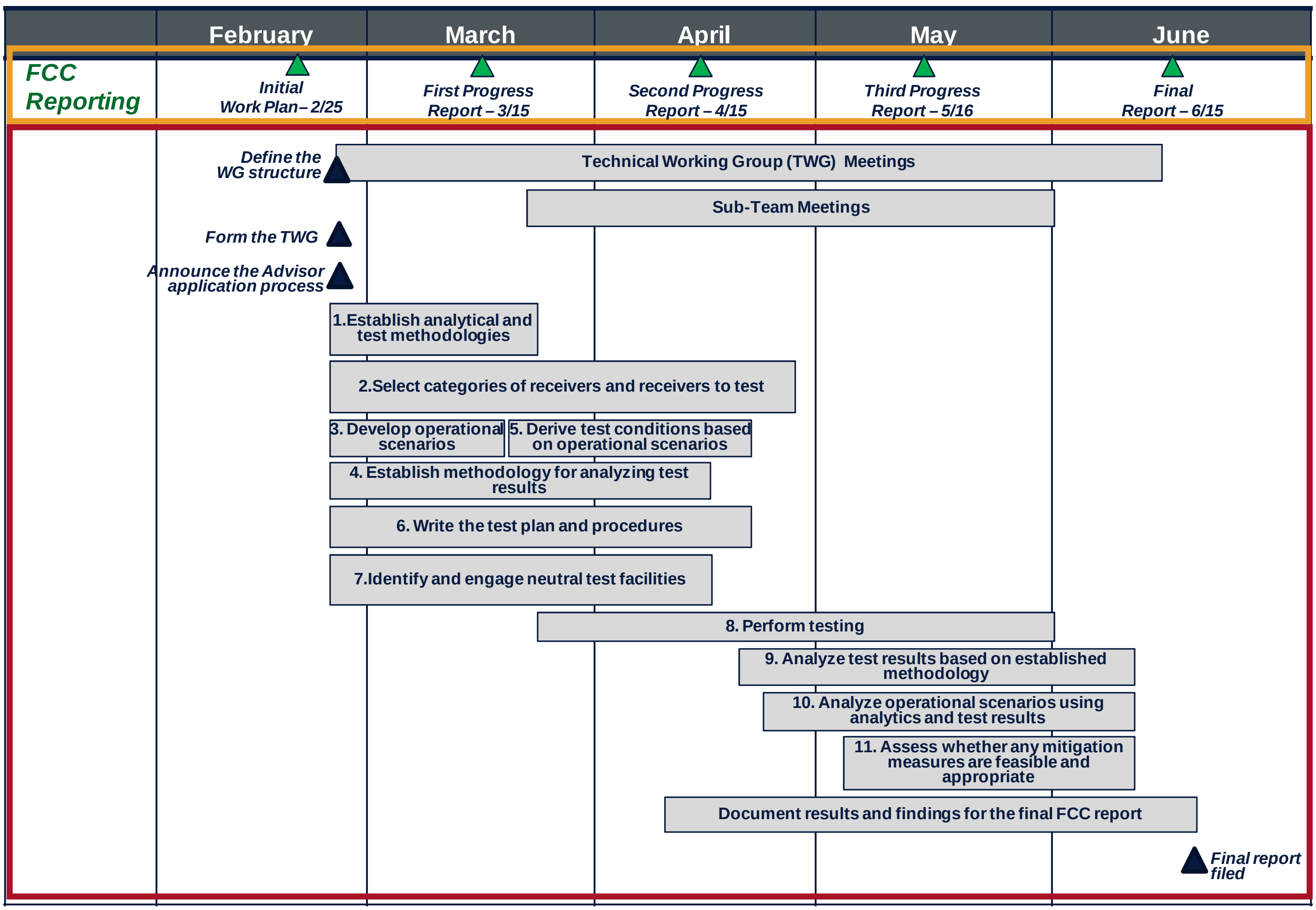
Testing is occurring during the period from May 16th to 27th, from midnight to 6AM (local time) daily. LightSquared is using base stations identical to the ones which it will use for its network deployment; however due to unique circumstances of the test setup, in single frequency mode, the test sites will operate at power levels of approximately 59 dBm EIRP per channel as opposed to the 62 dBm EIRP per channel currently planned for LightSquared's initial commercial deployment. For two carrier tests, the MIMO gain will not be present, reducing the EIRP a further 3 dB per channel to approximately 56 dBm EIRP (see Note 1 in Appendix G). It is broadcasting 5 MHz LTE carriers centered on 1528.8 MHz and 1552.7 MHz (separately and together) in 15 minute on/off cycles (longer cycles may be utilized to accommodate specific users' test requirements). A copy of the test setup is attached as Appendix G. LightSquared has coordinated these tests with CMRS and public safety operators in proximity to its test sites.

TWG members and advisors from several of the sub-teams are testing their own devices as part of the field test process, with the expectation that test results will be made available to the TWG (consistent with its device anonymity process); device-anonymous results will also be included in the TWG's final report on June 15.

Going-Forward Activities

The following updated timeline lays out the planned process and sequence of activities for the TWG up to and including the filing of the final report which is due to the FCC on June 15, 2011.

TWG Planned Process Timeline



List of Attachments

Appendix A	Working Group Roster
Appendix B	List of Receivers and Devices
Appendix C	Final Aviation Test Plan
Appendix D	Updated Cellular Test Plan
Appendix E	Updated General Location/Navigation Test Plan
Appendix F	Final High Precision Networks and Timing Test Plan
Appendix G	LightSquared Live-Sky Test Environment

APPENDIX A
GPS WORKING GROUP ROSTER

			SUB-TEAMS						
NAME	**AFFILIATION**	**ROLE**	**Aviation**	**Cellular**	**General Location /Nav**	**High Precision**	**Networks**	**Space-Based**	**Timing**
Maqbool Aliani	LightSquared	Advisor	X	X	X				
Dominic Arcuri	RCC	TWG Member							
Steve Baruch	USGIC	Observer							
Chaminda Basnayke	OnStar	Advisor			X				
Steve Berger	LightSquared	Advisor		X					
Michael Bergman	JVC-Kenwood Holdings	Advisor			X				
Knute Berstis	NCO/PNT	TWG Member				X			
John Betz	MITRE/USAF	TWG Member							
Mike Biggs	FAA	TWG Member	X						
Ron Borsato	Sprirent	Advisor		X					
Pierre Bouniol	Thales	Advisor	X						
Joe Brabec	Topcon Positions Sys.	Advisor				X			
Cady Brooks	BI	Advisor			X				
Greg Buchwald	Motorola Solutions	Advisor			X				X
Jim Buck	BI	Advisor			X				
Scott Burgett	Garmin	TWG Member			X				
Kevin Butler	Sprint Nextel	Advisor		X					
Bob Calaff	T-Mobile	Advisor		X					
Jeffrey Carlisle	LightSquared	WG Co-Chair							
Mark Cato	Airline Pilots Assoc.	Advisor	X						
Brett Christian	Sprint Nextel	Advisor		X					X
Ann Ciganer	Trimble	Info. Facilitator	X	X	X	X	X	X	X
Cormac Conroy	Qualcomm	Advisor		X					
Shawn Coppel	American Electric Power	Advisor					X		X
Charles Daniels	Overlook Systems Tech.	Advisor							
Wim De Wilde	Septentrio	Advisor				X			
Vinod Devan	LightSquared	Observer							
Santanu Dutta	LightSquared	TWG Member	X	X					
Rick Engelman	Sprint Nextel	TWG Member		X					X
Walter Feller	Hemisphere GPS	Advisor			X	X			
Pat Fenton	Novatel	TWG Member				X	X		Lead
John Foley	Garmin	TWG Member	X		X				
Collin Frank	Motorola Mobility	Advisor		X					
Hugo Fruehof	FEI-Zyfer	Advisor							X
Paul Galyean	Navcom	TWG Member				Lead	X		
Edward Gander	True Position	Advisor							X
Alex Gerdenitsch	Motorola Mobility	Advisor		X					
Henry Goldberg	LightSquared	Observer							
Capt. Anil Hariharan	USAF	TWG Member							
Martin Harriman	LightSquared	Info. Facilitator							
Scott Harris	Florida CORS Network	Advisor					X		
Chris Hegarty	MITRE/FAA	TWG Member	Lead						
Bronson Hokuf	Garmin	TWG Member			X				
Bruce Jacobs	LightSquared	Observer							
Jill Johnson	Leica Geosystems	Advisor				X			
Kevin Judge	Judge Software	Advisor		X	X				
Sai Kalyanaraman	Rockwell Collins	TWG Member	X					X	
Rich Keegan	Navcom	Advisor				X			
Jerry Knight	Navcom	TWG Member							
Galen Koepke	NIST	Advisor							X
Richard Kolacz	GSTS	Advisor							
Karl Kreb	Los Angeles County	Advisor							X
Rob Kubik	Samsung	Advisor		X					
Eric Kunz	Furuno USA	Advisor			X				
Joe Kuran	WCCCA	Advisor			X				X
Chris Kurby	LightSquared	Advisor		X					
John Lacey	Lockheed Martin	TWG Member							
Farokh Latif	APCO	TWG Member							
Rich Lee	LightSquared	TWG Member		Lead		X	X		
Alfred Leick	Univ. of Maine	Advisor				X			
Sanjay Mani	Symmetricom	Advisor							X
Keith Mathers	Sprint Nextel	Advisor							X
Amy Mehlman	LightSquared	Observer							
Charlie Meyer	Alcatel-Lucent	Advisor		X					X
Fred Moorefield	USAF	TWG Member							
David Mulholland	National Park Service	Advisor			X				
Tim Murphy	Boeing	TWG Member	X						
Pierre Nemry	Septentrio	Advisor				X			
David Overdorf	AT&T	Advisor							X
Ajay Parikh	LightSquared	Advisor	X						X
Gary Pasicznyk	City and County of Denver	TWG Member							
Gil Passwaters	Furuno USA	Advisor			X				X
Bruce Peetz	Trimble	TWG Member			X	X	Lead		X

			SUB-TEAMS						
NAME	**AFFILIATION**	**ROLE**	**Aviation**	**Cellular**	**General Location /Nav**	**High Precision**	**Networks**	**Space-Based**	**Timing**
Brian Poindexter	Garmin	TWG Member			X				
Gary Poon	Los Angeles County	Advisor							X
Tom Powell	Aerospace/USAF	TWG Member			X			X	
Scott Prather	AT&T	Advisor		X					
Olav Queseth	Ericsson	Advisor							X
Brian Ramsay	NASA	TWG Member						Liaison	
William Range	New Mexico E-911	Advisor		X					
Pat Reddan	Zeta/FAA	TWG Member	X						
Daniel Reigh	Lockheed Martin	TWG Member							
Mark Rentz	Navcom	TWG Member				X	X		
Stuart Riley	Trimble	TWG Member				X	X		
Raul Rodriguez	USGIC	Observer							
Narothum Saxena	USCellular	Advisor		X					
Michael Shaw	Lockheed Martin	TWG Member (Alternate)							
David Shively	AT&T	TWG Member		X					X
Patryk Siemion	LightSquared	Observer							
Mike Simmons	Garmin	TWG Member			Lead				
Joe Ben Slivka	Summit County, CO	Advisor			X				
Fraser Smith	Topcon Positions Sys.	Advisor				X			
Claudio Soddu	Inmarsat	Advisor				X			
Geoffrey Stearn	LightSquared	Info. Facilitator	X	X	X	X	X	X	X
Jim Sternberg	JS Engineering	Advisor							X
Bill Stone	Verizon Wireless	TWG Member		X					
Thomas Struzzieri	State of Virginia	Advisor			X				X
Mark Sturza	LightSquared	TWG Member	X						
Michael Swiek	USGIC	Info. Facilitator	X	X	X	X	X	X	X
Frank Takac	Leica Geosystems	Advisor					X		
Andreas Thiel	U-Blox	Advisor		X	X				
Lisa Thompson	Arlington County, VA	Advisor							X
Charles Trimble	USGIC	WG Co-Chair							
Michael Tseytlin	LightSquared	Advisor		X	X	X	X	X	
Greg Turetzky	CSR	TWG Member		X	X				
A.J. Van Dierendonck	USGIC	TWG Member	X		X	X			
Rick Walton	Lockheed Martin	TWG Member							
David Weinreich	Globalstar	Advisor		X	X	X	X		
Marc Weiss	NIST	Advisor							X
Vince Wolfe	TomTom	Advisor			X				
Arthur Woo	Furuno/eRide	Advisor			X				
Michael Woodmansee	Ericsson	Advisor							X
Larry Young	NASA	TWG Member				X		X	

APPENDIX B

LIST OF DEVICES AND RECEIVERS PLANNED FOR TESTING (SUBJECT TO CHANGE)

Aviation

- Canadian Marconi GLSSU 5024
- Garmin 300XL
- Garmin GNS 430W
- Garmin GNS 480
- Rockwell Collins GLU-920 multimode receiver
- Rockwell Collins GLU-925 multimode receiver
- Rockwell Collins GNLU-930 multimode receiver
- Symmetricomm timing card (used for an FAA automation system)
- WAAS NovAtel G-II ground reference station
- Zyfer timing receiver (used for the WAAS ground network)

Cellular

- Apple iPhone 4 (GSM)
- Apple iPhone 4 (CDMA)
- HTC A6366
- HTC ADR6200
- HTC ADR63002
- HTC ADR63003
- HTC ADR6400L
- HTC Desire 6275
- HTC Touch Pro 2
- LG Lotus Elite
- LG Rumor Touch
- LG VN250
- LG VS740
- LG VX5500
- LG VX5600
- LG VX8300
- LG VX8360
- LG VX8575
- LG VX9100
- LG VX9200
- Motorola A855
- Motorola DROID X
- Motorola VA76R
- Motorola W755
- Nokia 6650
- Nokia 6350

- RIM 8330C
- RIM 8530
- RIM 9630
- RIM 9650
- RIM 9800
- Samsung Moment
- Samsung SCH-U310
- Samsung SCH-U350
- Samsung SCH-U450
- Samsung SCH-U640
- Samsung SCH-U750
- Samsung SGHi617
- Samsung SGHi917
- Samsung Stride R330
- Samsung Messenger Touch
- Samsung Mesmerize i500
- Samsung Acclaim R880
- Sierra Wireless 250 U USG 3G/4G
- Sony Ericsson W760a

General Location/Navigation

- Garmin Forerunner 110 (Fitness)
- Garmin Forerunner 305 (Fitness)
- Garmin ETREX-H (Outdoor)
- Garmin Dakota 20 (Outdoor)
- Garmin Oregon 550 (Outdoor)
- Garmin GTU 10 (Tracking)
- BI Inc. ExacuTrack® One (Tracking)
- Garmin GPS 17X (NMEA) (Marine)
- Garmin GPSMAP 441 (Marine)
- GM OnStar Model TBD (Automotive (in dash))
- Garmin GVN 54 (Automotive (in dash))
- TomTom XL335 (PND)
- TomTom ONE 3RD Edition (PND)
- TomTom GO 2505 (PND)
- Garmin nűvi 2X5W (PND)
- Garmin nűvi 13XX (PND)
- Garmin nűvi 3XX (PND)
- Garmin nűvi 37XX (PND)
- Garmin GPSMAP 496 (Portable Aviation (non-TSO))
- Garmin aera® 5xx (Portable Aviation (non-TSO))
- Honeywell Bendix/King AV8OR (Portable Aviation (non-TSO))
- Trimble iLM2730 (with Mobile Mark Option J antenna) (Fleet Management)

- Trimble TVG-850 (with Mobile Mark Option E glass-mount antenna) (Fleet Management)
- Trimble Placer Gold (Emergency Vehicles (post-OEM mounted in vehicle))
- Furuno GP 33
- E-Ride Opus 5SD
- Motorola APX7000
- Motorola APX6000
- Motorola MW810

<u>High Precision and Networks</u>

- Hemisphere R320 (with A52 antenna)
- Hemisphere A320 (with Integral antenna)
- Deere iTC (with Integral antenna)
- Deere SF-3000 (with Integral antenna)
- Deere SF-3050 (with Aero antenna)
- Trimble MS990
- Trimble MS992
- Trimble AgGPS 252
- Trimble AgGPS 262
- Trimble AgGPS 442
- Trimble AgGPS EZguide 500
- Trimble CFX 750
- Trimble FMX
- Trimble GeoExplorer 3000 series GeoXH
- Trimble GeoExplorer 3000 series GeoXT
- Trimble GeoExplorer 6000 series GeoXH
- Trimble GeoExplorer 6000 series GeoXT
- Trimble Juno SB
- Trimble NetR9 (with Zephyr 1 antenna)
- Trimble NetR9 (with Zephyr 2 antenna)
- Trimble R8 GNSS (with Integral antenna)
- Trimble 5800 (with Integral antenna)
- Trimble NetR5 (with Zephyr 1 antenna)
- Trimble NetR5 (with Zephyr 2 antenna)
- Leica SR530 (with AT502 antenna)
- Leica GX1200 Classic (with AX1202 antenna)
- Leica GX1230GG (with AX1202GG antenna)
- Leica GR10 (with AR10 antenna)
- Leica Uno (with GS05 antenna)
- Leica GS15 (with Intergral antenna)
- Topcon HiPer Ga
- Topcon HiPer II
- Topcon GR-3 (with Integral (5/8) antenna)
- Topcon GR-5 (with Integral (5/8) antenna)

- Topcon MC-R3 (with MC-A3/cabled (5/8) antenna)
- Topcon NET-G3A (with CR-G3/cabled (5/8) antenna)
- Topcon TruPath/AGI-3 (with Integral (special mount) antenna)
- NovAtel PROPAK-G2-Plus (with GPS-702/GPS-701 antenna)
- NovAtel FLEXG2-STAR (with GPS-701GGL/GPS-701 antenna)
- NovAtel FLEXPAK-G2-V1 (with GPS-701GGL/GPS-702 antenna)
- NovAtel FLEXPAK-G2-V2 (with GPS-702GGL/GPS-702 antenna)
- NovAtel PROPAK-V3 (with GPS-702GGL/GPS-702 antenna)
- NovAtel DL-V3
- NovAtel FLEXPAK6 (with GPS-702GGL/GPS-702 antenna)
- Septentri PolaRx3e (with PolaNt GG antenna)
- Septentrio AsteRx3 (with PolaNt G antenna)

Space-Based Receivers (Testing Complete)

- TriG (NASA Next-generation Space Receiver)
- IGOR (Space Receiver)

NASA/JPL also tested the following high precision receivers; the results of these tests have been shared with the HPT&N sub-team for its consideration:

- JAVAD Delta G3T (High Precision-IGS)
- Ashtech Z12 (High Precision-IGS)

Timing

- FEI-Zyfer UNISync GPS/PRS (with Yokowo, part number YOP-5145-YN01 antenna)
- TruePosition GPS timing receiver (with 34043A antenna)
- Symmetricom SSU 2000 (Motorola M12M) (with 32012937-012-0 (GPS L1 26 dB) antenna)
- Symmetricom Time Provider 1000/1100 (Furuno GT-8031) (with 090-58545-01 antenna)
- Symmetricom TimeSource 3500 (XR5 (Navstar/Symmetricom), Wall Mount config. (with 012-00013-01 (Wall Antenna) antenna)
- Trimble Resolution T
- Trimble Accutime Gold
- Trimble Resolution SMT
- Trimble MiniThunderbolt
- NovAtel OEMStar (with Antcom 2G0 antenna)
- NovAtel OEM4 (with GPS600 antenna)
- NovAtel OEMV3 (with GPS702GG antenna

Appendix C

MOPS Based Procedure for Minimum Recommended Testing of LightSquared RFI to GPS Aviation Receivers

MOPS-Based GNSS Receiver Broad band RFI Test Procedures

The objective of the following tests is to evaluate the overload and desensitization impact of the LightSquared transmissions on the GNSS receiver. This impact is verified by evaluating GPS receiver performance metrics (critical to a certified aviation receiver) in the presence of LightSquared 3GPP Interferers.

MOPS-based GPS Receiver Overload RFI Effect Test Procedures

The intent of the following test procedures is to evaluate the impact of LightSquared's LTE (3GPP) signal transmissions on the GPS receiver's performance. The following test procedures focus on the application of Continuous Wave (CW) and broadband interferers at specific frequency ranges and varying power levels.

The simulation conditions used for the measurement accuracy tests in DO-229D [1] (Section 2.5.8) are used as a baseline for the purposes of evaluating the GNSS receiver's performance in the presence of these transmissions. Based on available information, it is observed that LightSquared's LTE (3GPP) transmission bandwidths will be 10 MHz wide (2 channels across 1526 – 1536 MHz and 1545.5 – 1555.2 MHz) during their final phase 2 deployment. The LTE downlink closest to the GPS band will be centered at 1550.5 MHz (1550.5 +/- 5 MHz). However, during the initial phase zero deployment, the LTE downlink is centered on 1552.7 and is 5 MHz wide (1550.2 to 1555.2 MHz).

For the purposes of the preliminary evaluation the total transmit power in the downlink band is assumed to be concentrated at a single frequency point (for e.g. at 1552.7 MHz). At the outset, the LightSquared signal is not expected to correlate with the GNSS signal. To validate this, the test will initially be performed with CW interference (CWI). The next step would be to utilize a signal generator to replicate the LightSquared transmissions and compare the receiver impact of these transmissions at varying power levels to that of the CWI. This will aid towards obtaining a correction factor between CWI and the LTE modulations. It will also help provide a reference point for the range accuracy SBAS message loss rate tests. The initial power levels of the LightSquared transmissions (for the baseline test conditions explained below) would be set at the same level as the GPS Receiver's CW Interference mask DO-229D Appdx. C).

The reported Carrier to Noise ratio (CNR) from the GPS Receiver is used as a yardstick of receiver performance. In addition, the pseudorange measurement accuracy (which reflects a critical receiver performance metric) and SBAS Message failure rates (for applicable units) will be evaluated at specific 3GPP Interferer signal levels. However, for a given receiver architecture, the range measurement accuracy is typically tied to the CNR.

Carrier-to-Noise Ratio (CNR) Degradation Baseline Test

The following depicts the test conditions used for comparison of relative impact of the CW interference versus the 3GPP LTE interferers.

CNR Degradation Baseline Test Satellite Simulator and Interference Conditions

The simulator and interference conditions shall conform to the following requirements:

1. For all test scenarios, the broadband GNSS test noise and $N_{sky,antenna}$ (-172.5 dBm/Hz) shall be simulated. A broadband external interference noise ($I_{Ext,Test}$) has a spectral density equal to -173.5 dBm/Hz at the antenna port.
2. The CW power and frequencies are listed in Table C-1. These CW frequencies are the mid band frequencies of the 5 and 10 MHz LTE 3GPP BTS bands that would be rolled out across Phases 0, 1A and 2.
3. The GNSS test noise depends on the number, power, and type of satellites simulated during the test. The power spectral density of the total GNSS Noise (I_{GNSS}) is -171.9 dBm/Hz (RTCA DO-235B [2], Appdx.F.2.3). This GNSS Noise was derived for GPS tracking but is used in the test for both GPS and SBAS tracking to allow simultaneous testing of GPS and SBAS thereby reducing test time. However it is acceptable to run the SBAS testing separately using a total GNSS Noise (I_{GNSS}) of -172.8 dBm/Hz for collection of the SBAS message loss rate data. The effective noise power spectral density (I_{Test}) of the satellites present in the simulator scenario may be removed from the total GNSS Noise; to do so, the satellite equivalent power spectral density specified in Table 0-2 (I_{GH}, I_{GL}, I_{SH}, and I_{SL}) is removed for each satellite present. The number of maximum power GPS satellites is N_{GH}, the number of minimum power GPS satellites is NGL, the number of maximum power SBAS satellites is N_{SH}, and the number of minimum power SBAS satellites is N_{SL}. The GNSS test noise is determined by removing I_{Test} from I_{GNSS} as follows:

$$I_{GNSS,Test} = 10log10[10^{-171.9//10} - 10^{I_{Test}/10}];\ \ where:$$

$$I_{Test} = 10log10[(N_{GL})10^{I_{GL}/10} + (N_{GH})10^{I_{GH}/10} + (N_{SL})10^{I_{SL}/10} + (N_{SH})10^{I_{SH}/10}]$$

Note: The indicated power levels (both signal and noise) are for the steady-state portion of the tests; power levels are set to the required values once steady state navigation has been achieved. Refer to Appendix M of DO-229D for an explanation of how I_{Test} is derived and examples of the computation of $I_{GNSS,Test}$ and how it may be applied. This appendix also provides guidance on how the test can be setup.

4. Simulated GPS and SBAS RF shall be at the minimum power level for the equipment. One GPS satellite shall be set to the maximum power level (including maximum transmit power and maximum combined satellite and aircraft antenna gain). At least two SBAS satellites shall be used.
5. When the setup uses an external amplifier to simulate the impact of the GNSS Antenna preamplifier (DO-301 [2] equivalent antenna), it is recommended that a net 30dB gain (to simulate maximum antenna pre-amp gain and minimum cabling loss) is implemented in order to evaluate the worst case impact of the 3GPP Interferers.

Table 0-1: STEADY STATE ACCURACY TEST CWI VALUES*

Frequency (MHz)	Power (dBm)	I/S (dB)
1528.8	**-22.2**	**111.8**
1531	**-28.1**	**105.9**
1550.2	**-79.6**	**54.4**
1552.7	**-86.4**	**47.6**

* The CWI power is specified at the antenna port. The actual level used during testing is reduced by the minimum frequency selectivity of the active antenna adjusted for any filtering in the test set-up itself. When demonstrating compatibility with a minimum standard antenna, the frequency selectivity is specified in RTCA/DO-301. When using a specific antenna, its minimum frequency selectivity can be used when determined in accordance with RTCA/DO-301. A block diagram of an example test setup is shown Figure 0-1.

Note: Care should be taken when applying non-L1 CW frequencies so that the L1 CW and broadband specifications are not exceeded.

Table 0-2: SATELLITE EQUIVALENT POWER SPECTRAL DENSITY

Satellite Type	Maximum Power Satellite	Minimum Power Satellite
GPS	I_{GH} = -183.5 dBm/Hz	I_{GL} = -196.5 dBm/Hz
SBAS	I_{SH} = -179.8 dBm/Hz	I_{SL} = -198.3 dBm/Hz

Note: These values of equivalent power spectral density were computed using the same assumptions as were used to determine the total GNSS Noise in Appendix C of DO-229D.

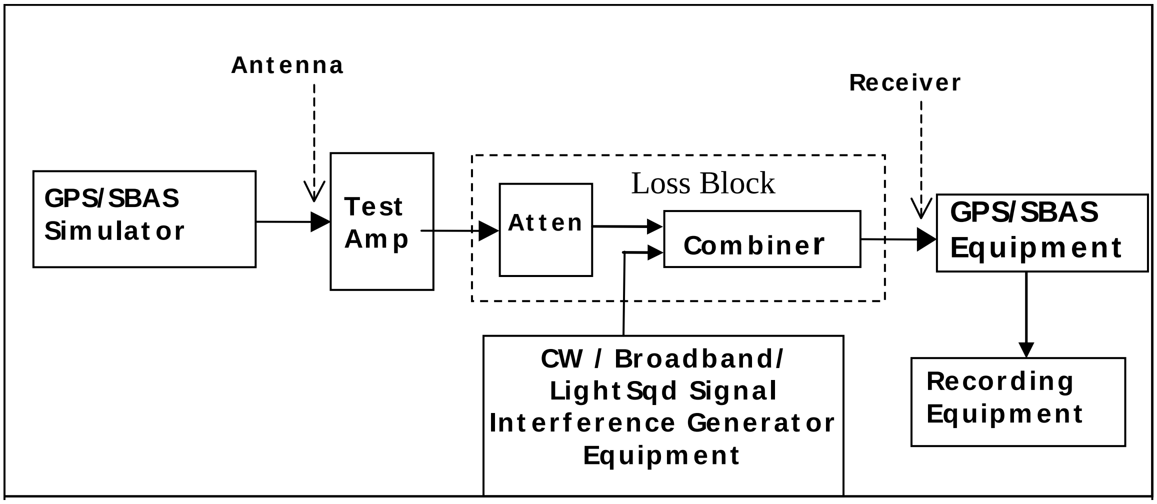


Figure 0-1: **EXAMPLE TEST SET-UP**

CNR Degradation Baseline Test Procedure

1) The test unit is connected to the RF signal and interference source.
2) The simulator scenario shall be engaged and the satellites RF shall be turned on.
3) The equipment under test shall be powered and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.
4) When the unit is navigating, the interference to be applied shall be applied to the equipment under test, and the power of the signal and interference shall be adjusted to the required level (at the appropriate freq. as seen in table 1).
5) At this base power level ensure that the unit meets the MOPS requirements per DO-229D. Record the CNR's of individual satellites (SBAS and GPS).
6) Increase the level of the CWI by 2 dB (this step size may be varied) and hold this level for 60 seconds.
7) Record the CNR's of the individual GPS SV's and the CWI level.
    1. If the CNR's on the SV's have not degraded go back to step (6).
    2. If the CNR is reduced by > 1dB, record the result for that RFI level and go back to the previous CWI level, ensure the unit attains the original CNR level and increase the CWI in smaller steps (in order to capture the CWI level that cause a 1dB degradation).
    3. Proceed to the next step.
8) Repeat steps 5-7 at the other CWI frequencies listed in Table 0-1.
9) Replace the CWI interference source with a signal generator that would replicate a 5 MHz bandwidth LTE (3GPP) signal transmission and repeat the test procedure (from step 1) for the 1528.8 and 1552.7 MHz frequencies.

10) Replace the CWI interference source with a signal generator that would replicate a 10 MHz bandwidth LTE (3GPP) signal transmission and repeat the test procedure (The starting point may be a I/S value somewhat less than in step 9, and using only center frequencies 1531.0 and 1550.2 MHz).

Note 1: A comparison of the unit's CNR degradation across both types on interference sources is helpful to verify the assumptions in interference analyses. The value from steps 9 and 10 are also used in subsequent higher level receiver performance tests in Section 3 and following sections. *Any receiver margin above the interference mask is considered as design margin.*

Note 2: As an option, the comparison test of Section 2 above may be performed for higher CNR degradation values.

Measurement Accuracy Test

The purpose of this Accuracy Test is to evaluate the equipment's accuracy performance under specific interference levels that have been ascertained from the CNR degradation test procedure (see 0). It is not intended to verify the accuracy of the atmospheric corrections; these corrections need not be included in the test. In order to meet the DO-229D MOPS requirements, the equipment must meet the accuracy requirements of Section 2.1.2.1, 2.1.3.1, and 2.1.4.1.3 of DO-229D.

Note: This evaluation method is based on the assumption that a least-squares position algorithm (per Section 2.1.4.1.4 of DO-229D) is implemented. If a different form of positioning is used, this evaluation method may not be appropriate.

Measurement Accuracy Test Satellite Simulator and Interference Conditions

The measurement accuracy test shall be performed under the following test conditions:

A. The baseline test condition (at the MOPS interferer levels) used in 0 with a modification to $I_{Ext,Test.}$ Use $I_{Ext,Test}$ of -170.5 dBm/Hz vs. -173.5 dBm/Hz.

B. The equivalent LTE (3GPP) broadband RFI signal level at which the receiver's estimated CNR is lower by 1dB from the baseline used in Section 0. (option: higher level CNR degradation values may be used as desired)

The total duration of each test case test shall be based upon sampling intervals required to obtain samples that are statistically independent. Independent samples collected during the initial acquisition and before steady-state operation are used for the validation of σnoise overbounding. The samples collected prior to steady-state operation should not be used for the steady-state RMS accuracy evaluation and the steady-state evaluation of $\left(\sigma^2_{noise}[i]+\sigma^2_{divg}[i]\right)^{1/2}$.

Note: It would be advantageous to extend the duration of this test to support evaluation of SBAS Message Loss Rate (for applicable receivers).

This test is performed for following cases (with the listed order of priority)

a. 5 MHz 3GPP Interferer BW at 1552.7 MHz

b. 5 MHz 3GPP Interferer BW at 1528.8 MHz

c. 5 MHz 3GPP Interferer BW's at both 1552.7 and 1528.8 MHz

d. 10 MHz 3GPP Interferer BW at 1531 MHz

e. 10 MHz 3GPP Interferer BW at 1550.2 MHz

f. 10 MHz Interferer BW's at both 1531 and 1550.2 MHz

It is recommended that the Doppler/delta range metrics on the tracked satellites (if available) be evaluated alongside the pseudorange accuracy procedure. This includes evaluation of the accuracy degradation of the Doppler/delta range measurement from the receiver, the Doppler/Delta range validity flag and available loss of code/carrier lock indicators. The measurement type (Doppler/delta range) and validity flag information is available on Label 060 (bits 21 and 22) on the ARINC standard 429 GNSS data bus. The measurement is found on Label 063/064 on this bus.

Measurement Accuracy Test Procedure

1) Perform steps 1 through 5 of 0. Sampling should begin for each satellite immediately after it is included in the navigation solution for the σnoise overbounding evaluation described in paragraph 4) below.

2) When steady-state accuracy is reached, data are recorded as follows:

3) Initially, 50 independent samples of pseudorange data are recorded at the required sampling interval (see note below).

Note: The sampling interval will be two times the integration interval used for carrier phase smoothing of pseudoranges. For example, if the integration interval used for carrier smoothing of the pseudoranges is 100 second, the sampling interval will be 200 seconds. If ten pseudoranges are collected per sampling interval (nine independent measurements), the duration of the initial data collection period will be 20 minutes.

4) The normalized RMS range error statistic, RMS_PR, is computed according to the following formula, using all collected samples (including those prior to steady-state operation):

$$RMS\_PR(M) \equiv \sqrt{\frac{\sum_{j=1}^{M} \left\{ \sum_{i=1}^{N_j} \frac{Z_{ij}^2}{\left[\sigma_{norm,ij}^2 N_j\right]} \right\}}{M}}$$

where:

$$Z_{ij} \equiv PR_{ij} - R_{ij} - (c\Delta t)_j$$

$$(c\Delta t)_j \equiv \frac{1}{N_j} \sum_{i=1}^{N_j} \left(PR_{ij} - R_{ij}\right)$$

$$\sigma^2_{norm,ij} = \frac{\left[\left(N_j - 1\right)^2 \sigma^2_{noise,ij} + \sum_{\substack{k=1 \\ k \neq i}}^{N_j} \sigma^2_{noise,kj} \right]}{N_j^2}$$

where:

PR_{ij} = smoothed pseudo-range, channel i, time j

R_{ij} = true range, satellite i, time j (includes extrapolation)

N_j = number of satellites at time j

M = number of sampling intervals

$\sigma_{noise,ij}$ = satellite i, time j (refer to Appendix J.2.4 of the DO-229D MOPS)

Note 1: Interchannel biases on the simulator may impede the accuracy test specified herein. It may be necessary to determine this bias and inflate the test threshold based upon equipment calibration. If two receivers are used to remove this bias (via double-differencing), the test must account for potential interchannel biases in the receivers themselves and cannot simply remove all bias components.

Note 2: Since code-carrier divergence is not simulated in this test, the σ_{divg} term is not used in this normalization. Validation of σ_{divg} should be accomplished by analysis.

5) Verification of σnoise overbounding: The error statistic is compared to the 110% Pass Threshold of Table 0-3 based on the Number of Independent Samples (NIS), where NIS is given by:

$$NIS(M) \equiv \sum_{j=1}^{M} \left(N_j - 1\right)$$

If RMS_PR is below the pass threshold (Table 0-3), the result is a pass. If the RMS_PR is not below the pass threshold, additional data may be collected. In this case, the RMS_PR shall include the initial independent samples plus all additional data, and the formulas and pass criteria of this section (which apply for an arbitrary number of samples) shall be used.

Note: It is expected that the pass criteria will not be met with the initial data collection (only the initial acquisition and 50 steady-state operation independent samples due to the limited sample size. Development of the test criteria, and the associated pass probabilities are described in Appendix M of DO-229D.

6) Steady-state value of $\left(\sigma^2_{noise}[i] + \sigma^2_{divg}[i]\right)^{1/2}$: Using only those samples collected during steady-state, the average $\left(\sigma^2_{noise}[i] + \sigma^2_{divg}[i]\right)^{1/2}$ output values for each satellite are compared to the requirements of Appendix J.2.4 of DO-229D. The output values must be less than or equal to the required accuracy values for the designator of the equipment.

7) Verification of RMS accuracy: The steps defined in paragraph 3 and 4 are repeated using only those samples collected during steady-state operation and using the required RMS accuracy (sections 2.1.4.1.3.1 and 2.1.4.1.3.2) (minus any steady-state value of σ_{divg}) instead of the output $\sigma_{noise,i,j}$ in the computation of $\sigma_{norm,i,j}$. The pass criteria defined in paragraph 4 applies.

Table 0-3: PASS THRESHOLD TABLE

NIS	110% Pass Threshold	125% Pass Threshold
25-50	N/A	1.084
50-75	0.954	1.137
75-100	0.981	1.159
100-150	0.998	1.172
150-200	1.017	1.187
200-300	1.028	1.196
300-400	1.042	1.206
400-500	1.050	1.212
500-750	1.055	1.216
750-1000	1.063	1.222
1000-1250	1.068	1.226
1250-1500	1.072	1.229
1500-2000	1.074	1.231
> 2000	1.078	1.233

Note: The 110% pass threshold yields a 10% probability of passing equipment with a true accuracy of 110% of the required accuracy. The 125% pass threshold yields an 80% probability of failing equipment with a true accuracy of 125% of the required accuracy.

SBAS Message Loss Tests

The purpose of this test is to evaluate the loss rate of SBAS messages at degraded CNR's as a result of the LightSquared 3GPP LTE transmissions. Typically, SBAS Message Loss Rate requirements in Section 2.1.1.3.2 of DO-229D will need to be met at the minimum operating conditions (DO-229D Section 2.1.1.10) in the presence of DO-229D Appendix C interference conditions. In this case, the Message Loss rate requirement (Message Loss Rate < 1 in 1000 messages) is evaluated under interference conditions that also include the 3GPP interferers. This test will help evaluate 3GPP power levels at which the receiver does not meet the SBAS message loss requirement. Data necessary for this test may be collected concurrently during the tests in 0 (by extending the period of time for the test in 0).

Note 1: SBAS message loss information is typically not provided on the standard ARINC data outputs from a GNSS receiver. Instrumentation data from the GPS receivers may need to be used to obtain this information from the GPS receiver.

Note 2: It is expected that the SBAS message loss rate threshold would be exceeded prior to exceeding the pseudorange accuracy threshold.

REFERENCES

[1] RTCA, *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment*, Washington, D.C., RTCA DO-229D, Dec. 13, 2006.
[2] RTCA, *Assessment of Radio Frequency Interference Relevant to the GNSS L1 Frequency Band*, Washington, D.C., RTCA DO-235B, March 13, 2008.
[3] *Minimum Operational Performance Standards for Global Navigation Satellite System (GNSS) Airborne Active Antenna Equipment for the L1 Frequency Band*, Washington, D.C., RTCA DO-301, December 13, 2006.

Appendix D

Evaluation of
3GPP Band 24 (MSS L-band) ATC impact to Cellphone GPS Receivers

Version 1.2
May 15, 2011

Table of Revisions (partial to v 0.8)

Revisions	Author	Comments
Version 1.0	Edit team	Converged subgroup amendments to v0.8 (S.Datta)
Version 1.1	S. Datta	Caught up revisions proposed by Qualcomm to v1.0
Version 1.2	R. Lee	Formatting

1. Introduction

This document describes the test methodology to be used by the Cellular Subgroup of the GPS Technical Working Group (TWG) for overload testing of cell phone-based GPS receivers in proximity to LightSquared's base stations and UE's using 3GPP Band 24[2] (henceforth referred to simply as Band 24).

The tests shall accommodate both conducted and radiated cases. Conducted testing is preferred where a suitably connectorized device is available. Radiated testing shall be performed when such a device is not available. For checking correlation of results obtained by the two methods, radiated testing will be performed for some (at least 3) devices which are also subjected to conducted testing.

The testing will be based on industry standards but a number of extensions will need to be made as (a) none of the current standards specify performance testing with adjacent band interference, (b) the standards do not stress the capabilities of modern receivers to their sensitivity limits, and (c) the standards do not correspond to all use cases of interest with respect to distribution of satellite power levels.

The following standards will be used as the bases of the tests described here. Both UE based and UE assisted AGPS devices will be tested.

- 3GPP 34.171: AGPS Minimum Performance for WCDMA/HSDPA devices (suitable for connectorized testing of 3GPP devices) [1]
- TIA-916: AGPS Minimum Performance for CDMA devices (suitable for connectorized testing of 3GPP2 devices) [2]
- CTIA v3.1: AGPS Radiated test plan for CDMA and WCDMA/HSDPA devices: suitable for radiated testing (in a chamber) of both 3GPP and 3GPP2 devices [3]

While most of the testing will emulate proximity to LightSquared base stations, some testing time will be dedicated to emulation of overload caused by proximate LightSquared UE's.

2. Lab Test Methodology

Devices will be exposed to Band 24 power from signals that are representative of LightSquared's planned ATC base stations and UE's. The planned levels and spectrum occupancies are shown in Figure 2; high level block diagrams of the test set up are show in Figure 3 and 3.

The exposure of GPS devices to high power ATC signals will be emulated through the use of conducted injection of adjacent band signals into the device under test (DUT), as well as radiated injection of the same in an anechoic chamber. Care will be taken to ensure that the out-of-band-emission (OOBE) power spectral density (PSD) of the emulated base station signals in the RNSS band (1559 – 1605 MHz), relative to the in-band power of the Band 24 signal, is consistent with LightSquared's base station

[2] Per ITU designation, this is also referred to as the MSS L-band and is at: 1525 – 1559 MHz for downlink transmissions and 1626.5 – 1660.5 MHz for uplink transimmions.

emission mask, which specifies a 125 dB reduction[3] between the in-band and out-of-band PSD in the RNSS band. Special LS provided transmit filters will be used that will ensure that, in conjunction of the PSD roll off of the LTE signal, the emulated base station signals have a PSD at the L1 frequency that is at least 16 dB below the system noise floor of the GPS receiver at the antenna connector, for all blocker power levels at which a measurement is performed. Instead of true LTE signals, bandpass filtered Gaussian noise, with an in-band PSD characteristic similar to that of 5 MHz wide LTE, may be substituted.

For testing with Band 24 UE signals, LTE signal generators producing out-of-band emissions according to 3GPP TS 36.101, Band 24, and transmitting at the corresponding uplink frequencies must be used. The special transmit filters may not be necessary with low OOBE signal generators like the R&S SMU200A, depending on the blocker level used. This subject is still under study. Appropriate bandpass filters suitable for uplink interference testing have been ordered by LightSquared and will be used if required.

Appendix I provides an example of test equipment that may be used in the lab setups.

2.1. Test Summary

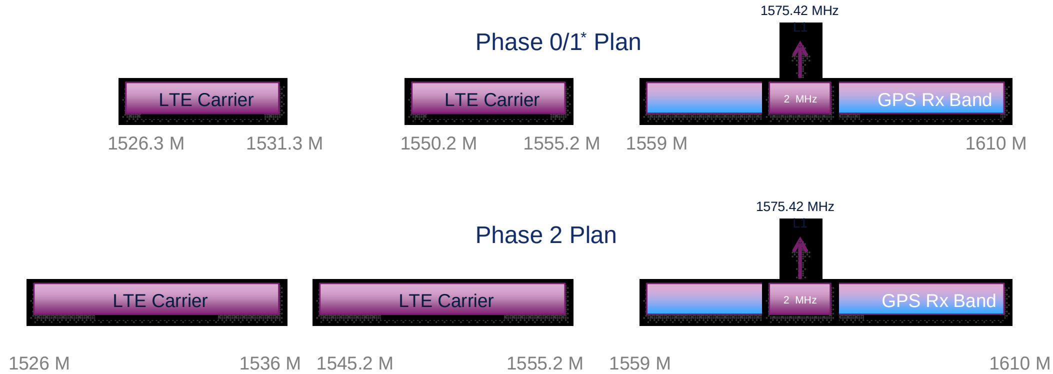
The performance of each device under test (DUT) will be tested in the presence of simulated Band 24 downlink and uplink signals and simulated GPS satellite signals from a signal generator. This GPS simulator has the ability to create a summation of received GPS signals from different satellites (space vehicles, or SV's).

2.2. Lab Test Variables

The GPS constellation on the GPS signal generator will be configured with 8 SVs. The GPS received signal power settings will be set as described in the individual test cases described below.

Tests will be performed for the spectrum occupancy corresponding to Phase 1 (two 5 MHz LTE carriers) as shown in Figure 2. Phase 1 is selected as it is likely to comprise the worst case in terms of overload potential – it creates 3rd order IM products at the L1 frequency and has the highest power density closest to the RNSS band. Testing will also be performed with the 5 MHz LTE carriers individually – this may show whether 3rd order IM products are a major contributor to any observed performance degradation. At the discretion (basis TBD) of the TWG Cellular Subgroup, some devices may also be subjected to testing with Phase 2 signals.

[3] The 125 dB rejection is based on transmitting 32 dBW in a 5 MHz carrier (resulting a PSD of 25 dBW/MHz) and achieving a PSD of -100 dBW/MHz in the RNSS band (1559 – 1605 MHz).



*Only upper 5-MHz LTE carrier is used in Phase-0. Both 5-MHz carriers are used in Phase-1

Figure 2: LightSquared Downlink LTE Band 24 and GPS Band (EIRP per carrier: 32 dBW)

2.3. Lab Environment

The Figure 3 and 3 below show the lab test setup for conducted and radiated mode testing, respectively. It is noteworthy that these figures only show the 2x10 MHz Phase 2 deployment (as an example).

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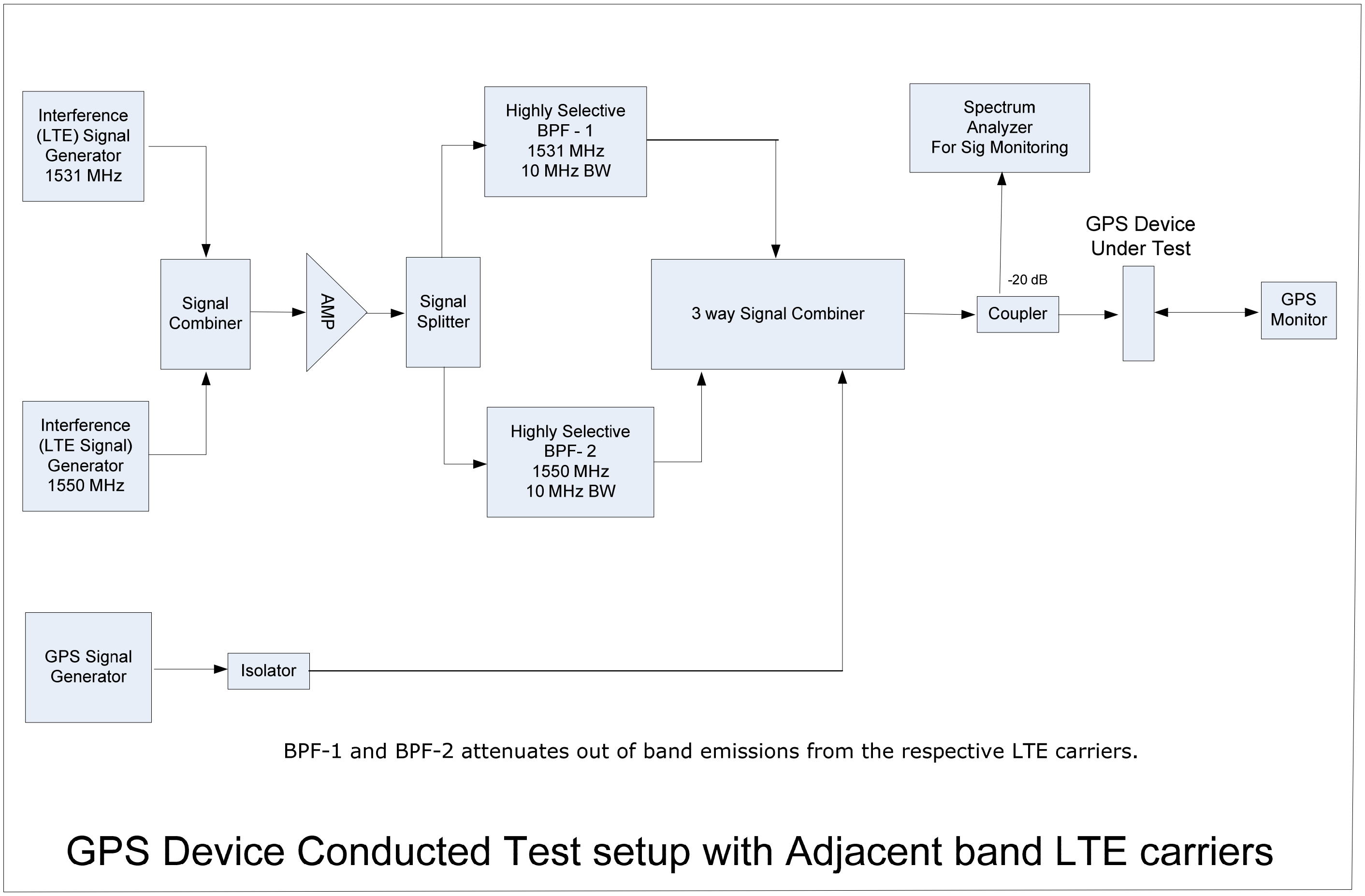


Figure 3: Lab Setup for GPS Device Conducted Test (Overload from BTS signal).

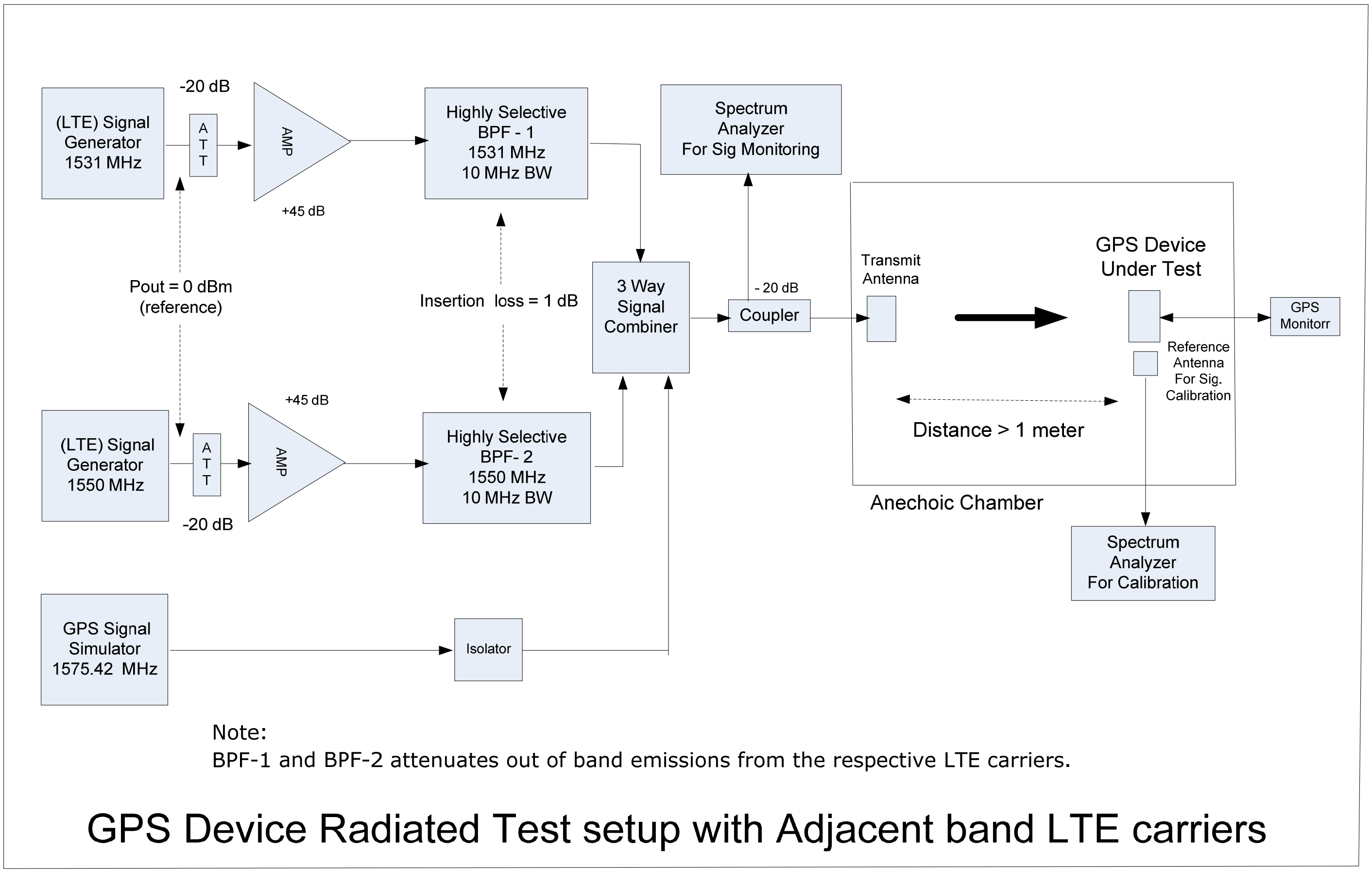


Figure 3: Lab Setup for GPS Device Radiated Test (Overload from BTS signal).

2.4. Test Execution

The tests described below will be performed. All tests are foundationally based on the standards specified in Section 1.

The following key performance indicators (KPI's), as defined in the relevant standards, will be logged:

a. 2D position error[4]
b. Response Time

C/N_0, as reported by the GPS, receiver will also be logged if it is available on the accessible interfaces of the receiver. Furthermore, the GPS SV power level will also need to be logged in order to perform the tests as per the standards.

[4] It is recognized that, in the case of UE based position reporting (contrasted with UE assisted position reporting), special software (non-native to the UE) may be required to read position measurements logged by the UE.

In addition to determining the threshold values of Band 24 power levels where "failure", as defined in the standards, is encountered, all tests will be extended to higher levels of Band 24 power until any one of the following conditions is met:

- lock cannot be maintained simultaneously on at least 3 satellites (i.e. the 4^{th} satellite encounters consistent loss of lock, as observed continuously over a period of time to be finalized by the test team)
- the device fails to provide a GPS-based position report
- the Band 24 Signal power at the DUT antenna connector exceeds -20 dBm.

The KPI's described above will be recorded as functions of Band 24 power levels from zero power until any one of the conditions described above is met. There is no pass/fail criterion in this test – simply logging of KPI's at different blocker power levels. In this document, this is referred to as *full range testing*.

When testing at blocker levels beyond the point where a defined pass/fail criterion has been met, the number of trials at each blocker level will be set at a fixed number (75) and the 67% and 95% values of the KPI will be recorded.[5]

It is recommended that, procedurally, the testing for pass/fail criteria be conducted from an assumed catastrophic blocker level (e.g. --20dBm) and then reduced to no blocker. This is to ensure that test system starts with the minimum number of trials and then increments up to the maximum. Notwithstanding the above, the testing team may propose alternate methods of optimizing the test execution.

It is noteworthy that all tests described below must be performed separately for Band 24 signals corresponding to base station and UE.

It shall be ensured that tests performed with and without Band 24 signals, for a given test environment, use exactly the same satellite constellations.

As multiple labs will be used, some devices will be used as common objects and subjected to the same tests at different labs to check calibration across test sites.

2.4.1 Connectorized Device 3GPP tests

The following tests, based on 3GPP 34.171 [1] will be performed. It is noteworthy that the test values in the following sections are subject to the test tolerances in Table F.2.1 of TS 34.171 [1].

2.4.1.1 AGPS Sensitivity test with Coarse Time Assistance *as per standard*

[5] Alternative percentile values of the CDF and the number of trials may be proposed by the testing team and used if approved by the TWG Cellular Subgroup.

This test will exactly follow [1, Section 5.2.1], except for the addition of Band 24 signals. A permitted exception is that the number of trials used may change from [1] to speed test time, while giving up some confidence. The sensitivity without interference will be tested using the trial methodology of [1][6]

It is noteworthy that the SV levels for this test are set as follows [1, Section 5.2.1.2].

GPS signal for one satellite: -142 dBm
GPS signals for remaining (7) satellites: -147 dBm

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.2.1.4] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.1.2 AGPS Sensitivity test with Coarse Time Assistance at *minimum, uniform SV power levels*

This test will exactly follow [1, Section 5.2.1], except for the addition of Band 24 signals and the use of lower SV power levels. The test will determine, for a given DUT, the lowest set of SV power levels at which the test will pass as per [1, Table 5.2.1.4], while maintaining the same number of SV's and relative SV power levels as in [1, Section 5.2.1]. This makes the test essentially similar to the CTIA OTA Sensitivity test of [3, Section 6.12.2.1].

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.2.1.4] is met (the result is a pass), with the provision that, when a blocker signal of non-zero-power is applied, the minimum SV power levels determined above will be increased uniformly (for all SV's) by 1 dB.

2.4.1.3 AGPS Sensitivity Test with Coarse Time Assistance at *discrete, uniform SV power levels*

The test of ([1], Section 5.2.1) will be performed at the following discrete levels for the 7 lower powered SV's instead of the -147 dBm in the standard: -135, -149, -152 dBm. The 8th SV is 5 dB above the other 7 SV's for each case. The testing is identical to that described in Section 2.4.1.1 in all other respects.

2.4.1.4 AGPS Nominal Accuracy test *as per standard*

This test will exactly follow [1, Section 5.3], except for the addition of Band 24 signals.

It is noteworthy that the SV levels for this test as set as follows [1, Section 5.3.5].

GPS signals for all (8) satellites: -130 dBm

[6] Number of trials still under development in [1]

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.3.4] is met (the result is a pass). Note the number of trials used presently follows [1] but is under sturdy.

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.1.5 AGPS Performance Test with *different SV power levels*

This test will exactly follow [1, Section 5.3], except for the addition of Band 24 signals and the use of the following SV power levels: -125, -128, -131, -134, -137, -140, -143, -146 dBm.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.4.2][7] is met (the result is a pass). Note the number of trials used presently follows [1] but is under sturdy.

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2 Connectorized Device 3GPP2 tests

The following tests, based on TIA-916 [2] will be performed on 3GPP2 compliant devices. All general requirements mentioned in Section 2.4 also apply here.

2.4.2.1 GPS Sensitivity Test *as per standard*

The test will exactly follow ([2], Section 2.1.1.3) except for the addition of Band 24 signals.

Per standard, the mobile device will return a **Provide Location Response** message if the mobile station is capable of location computation; or it shall return one or more **Provide Pseudorange Measurement** messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.3.2]. In summary, the GPS SV signal levels will -147 dBm with C/No of 27 dB-Hz with 4 SVs visible.

The pass/fail criterion is as per the minimum standard set forth in [2, Table 2.1.1.3.3-1]. In summary the mobile device will provide the Pseudorange Measurements and Location Responses within the limit values defined in applicable table.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3-1] is met (the result is a pass).

---

[7] The pass/fail criterion from the Dynamic Range test of [1] is used here owing to the similarity (although not exact identity) to the above test in [1]. It was decided to keep the constellation identical between the tests of Sections 2.4.1.5 and 2.4.2.5, which is based on the Dynamic Range test in [2]; hence a deviation was made for the present test relative to the standard.

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2.2 GPS Sensitivity Test at *minimum, uniform SV power levels*

The test will exactly follow [2, Section 2,1.1.3] except for the addition of Band 24 signals and the use of alternative satellite signal levels.

Per standard, the mobile device will return a **Provide Location Response** message if the mobile station is capable of location computation; or it shall return one or more **Provide Pseudorange Measurement** messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.3.2]. Instead of the SV levels used in the standard test case, this test will *determine* the minimum GPS SV signal level, with 4 SV's visible, where the pass/fail criterion defined in [2, Table 2.1.1.3.3-1] is passed.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3] is met (the result is a pass) with the provision that, when a blocker signal of non-zero-power is applied, the minimum SV power levels determined above will be increased uniformly (for all SV's) by 1 dB.

2.4.2.3 GPS Sensitivity Test at *discrete, uniform SV power levels*

The test of ([2], Section 2.1.1.3) will be performed at the following discrete SV levels: -135, -149, -152 dBm instead of the -147 dBm in the standard. The testing is identical to that described in Section 2.4.2.1 in all other respects. It is noted that the different SV power levels will be associated with different C/N_0 values, derived using a fixed N_0 of -174 dBm/Hz as is implied by ([2], Table 2.1.1.3.2-1).[8]

2.4.2.4 GPS Accuracy *as per standard*

The test will exactly follow [2, Section 2.1.1.1] except for the addition of Band 24 signals.

Per standard, the mobile device will return a **Provide Location Response** message if the mobile station is capable of location computation; or it shall return one or more **Provide Pseudorange Measurement** messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.1.2]. In summary the GPS SV signal levels will be -130 dBm with C/No of 44 dB-Hz with 8 SV's visible.

[8] In [2, Table 2.1.1.1.3-1] an SV power level or -147 dBm is specified along with C/N_0 of 27 dB.Hz. From, this N_0 = -147-(-27) = -174 dBm/Hz.

The pass/fail criterion is defined per the minimum standard set forth in [2, Table 2.1.1.1.3-1]. In summary the mobile device will provide the Pseudorange Measurements and Location Responses within the limit values defined in the applicable table.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3-1] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2.5 GPS Performance Test with *non-uniform SV power levels*

The test will be performed as exactly defined in Section 2.4.2.4 with the following exception: the following SV power levels will be used: -125, -128, -131, -134, -137, -140, -143, -146 dBm.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.2.3-1][9] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.3 Radiated Tests

The objective is to run the tests described in Sections 2.4.1 and 2.4.2 (which are connectorized tests based on [1] and [2]) in a radiated environment by leveraging the CTIA OTA tests [3].

The blocker signal is added linearly to the SV signals and injected into the chamber from the direction of maximum gain. The latter is first determined as *relative gain* in 3D using standard methods described in [3] and the angle-of-arrival (AoA) corresponding to maximum gain is ascertained.

Knowledge of the SV and blocker power levels is necessary in the tests of Section 2.4.3.2. These are estimated using the method described in Appendix II.

Note that Appendix II describes using the C/N_0 reported by the GPS receiver to establish the GPS power representing -130dBm at C/no=44dB-Hz. All other levels both GPS and LTE band 24 are relative to the level provided to the Tx antenna to establish -130dBm.

2.4.3.1 Sensitivity Test *(minimum, uniform SV power levels)*

The *minimum SV level* sensitivity tests described in Sections 2.4.1.2 and 2.4.2.2 are essentially identical to the Sensitivity test defined in [3, Section 6.12.2.1] without the blocker. This test will be run both with and without the blocker to determine the relative impact of the blocker.

[9] The pass/fail criterion from the Dynamic Range test of [2] is used here owing to the similarity to the above test in [2].

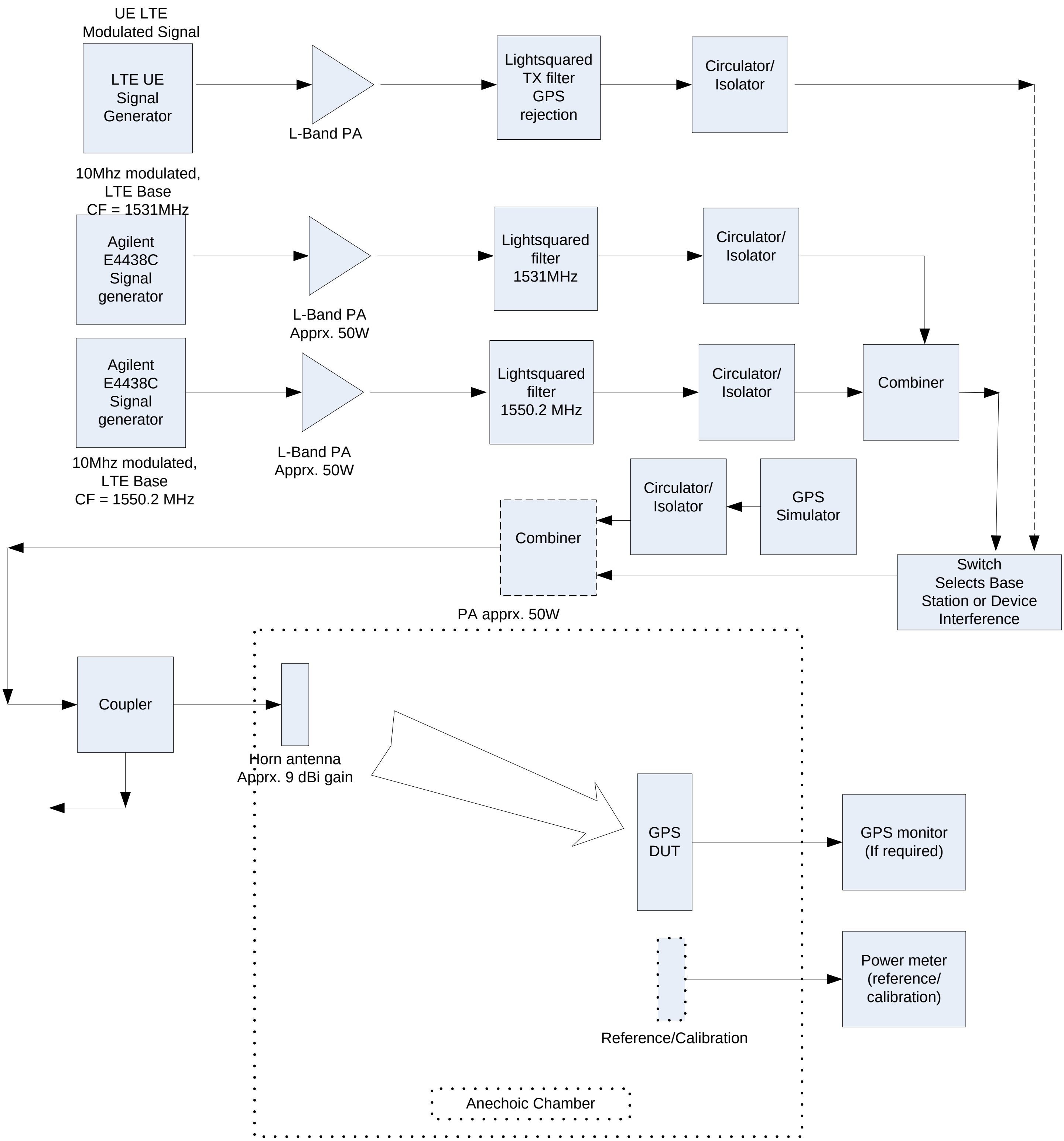
As in Sections 2.4.1.2 and 2.4.2.2, to determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in Sections 2.4.1.2 and 2.4.2.2 are met (the result is a pass), with the provision that, when a blocker signal of non-zero-power is applied, the minimum SV power levels determined above will be increased uniformly (for all SV's) by 1 dB.

2.4.3.2 Other tests based on [1] and [2]

Tests described in Sections 2.4.1.1, 2.4.1.3 - 2.4.1.5 and Sections 2.4.2.1, 2.4.2.3 - 2.4.2.5 fall in this category. All of these tests will be performed as *virtual connected mode tests* by injecting the composite signal (SV plus blocker) from the AoA corresponding to the maximum antenna gain of the DUT. The SV and blocker power levels will be estimated as described in Appendix II.

Appendix I

This section shows an example block diagram for a radiated test setup and is followed by a suggested equipment list.


UE LTE
Modulated Signal
LTE UE
Signal
Generator
L-Band PA
Lightsquared
TX filter
GPS
rejection
Circulator/
Isolator
10Mhz modulated,
LTE Base
CF = 1531MHz
Agilent
E4438C
Signal
generator
Lightsquared
filter
1531MHz
Circulator/
Isolator
L-Band PA
Apprx. 50W
Agilent
E4438C
Signal
generator
Lightsquared
filter
1550.2 MHz
Circulator/
Isolator
Combiner
10Mhz modulated,
LTE Base
CF = 1550.2 MHz
L-Band PA
Apprx. 50W
Circulator/
Isolator
GPS
Simulator
Combiner
Switch
Selects Base
Station or Device
Interference
PA apprx. 50W
Coupler
Horn antenna
Apprx. 9 dBi gain
GPS
DUT
GPS monitor
(If required)
Power meter
(reference/
calibration)
Reference/Calibration
Anechoic Chamber

Example Equipment List

Band-24 Chain

Number required	Equipment	Manufacturer	Model
2	Vector Signal Generator (used to generate LTE signals for Base Station)	Agilent	E4438C w/ Options: 005 – Hard Drive 602 – Dig Bus Baseband 1E5 – High Stability Time Base 503 – 250 kHz to 3 GHz
1	LTE Signal Generator (used to generate LTE signals for UE)	Agilent	E4438C
2	Amplifier	Comtech	ARD8829 50 or ARD88285 50
2	Band Pass Filter	Lightsquared	1531MHz and 1550.2MHz
2	RF Isolator	MECA	CN 1.500
2	Power Combiner	MECA	H2N - 1.500V
1	Directional Coupler	Mini Circuits	ZGDC20-33HP
Multiple	Cable	Microwave Systems	LMR200
2	Transmission Antenna and Reference/Calibration antenna	AH Systems	SAS-751 Horn 9.5dBi gain
1	Power meter reference and calibration	Agilent	E4419B

GPS Chain

Number required	Equipment	Manufacturer	Model
1	GPS Simulator	Spirent	Spirent GSS6700, GSS6560, or GSS5060
1	Transmission Antenna	ETS-Lindgren	3201 Conical Antenna (RHCP)
Multiple	Cable	Microwave Systems	LMR200
N/A*	Power meter reference and calibration	Agilent	E4419B
N/A*	Reference/Calibration antenna	AH Systems	SAS-751 Horn 9.5dBi gain

* - The same equipment can be used for both the L-band chain and the GPS chain as they are for calibration.

Recommended configuration of LTE Signal from Base Station

If using the Agilent E4438C ESG vector signal generator, the latter needs to be loaded with the Agilent N7624B Signal Studio with the 3GPP LTE FDD option package.

Name	Setting	Comment
Center frequencies	For 2 x 5 MHz Downlink channels LTE Carriers centered @ 1552.7 MHz and @ 1528.8 MHz, BW:5 MHz For 2 x 10 MHz Downlink channels LTE Carriers centered @ 1531 MHz and @ 1550.2 MHz , BW:10 MHz	According to test
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Frame Duration	10 ms	
Sub frame Duration	1.0 ms	
Subcarrier Modulation	QPSK	For PCH , PDCCH, PDSCH
Subcarrier Size	15 KHz	
Channel Bandwidth	5/10 MHz	According to test
PRB Bandwidth	0.180 MHz	
Sampling Rate	7.68 MHz / 15.36 MHz	According to channel size 7.68 MHz for 5MHz channel and 15.36 MHz for 10 MHz channel
FFT Size	512/1024	According to channel size 512 for 5MHz channel and 1024 for 10 MHz channel
Dummy Data	PN9	

Recommended configuration of LTE Signal from UE

The Rohde and Schwarz CMU200A Vector Signal Generator, configured with worst case scenario for GPS interference - device operating at the lowermost single RB of lower LTE channel with full power

Name	Setting	Comment
Center frequencies	LTE Carriers centered @ 1632.5 MHz	According to test
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Allocation	1 Leftmost RB Frequency 1628-1628.180	
RB Bandwith	180 kHz	
UE power	23 dBm	
Subcarrier Modulation	QPSK	
Dummy Data	PN9	

A-GPS Systems Required for Test Plan Execution

Spirent A-GPS Test systems will be used to conduct the 3GPP2 TIA-916, 3GPP 34.171, and CTIA OTA testing. In addition, specific scripts will be provided by Spirent to automate the Interferer setup and power level sweeps in conjunction with A-GPS performance testing and metric analysis. The following Spirent solutions are required for this test plan:

2.4.1 Connectorized Device 3GPP tests:

- Spirent 8100-A500 UMTS Location Test System (ULTS)
- Test Pack: TM-LBS-3GPP-TS34.171

2.4.2 Connectorized Device 3GPP2 tests

- Spirent C2K-ATS Position Location Test System (PLTS)
- Test Pack: PLTS-MP-SET (PLTS C.S0036 SOFTWARE BUNDLE)

2.4.3 Radiated Tests (UMTS Devices)

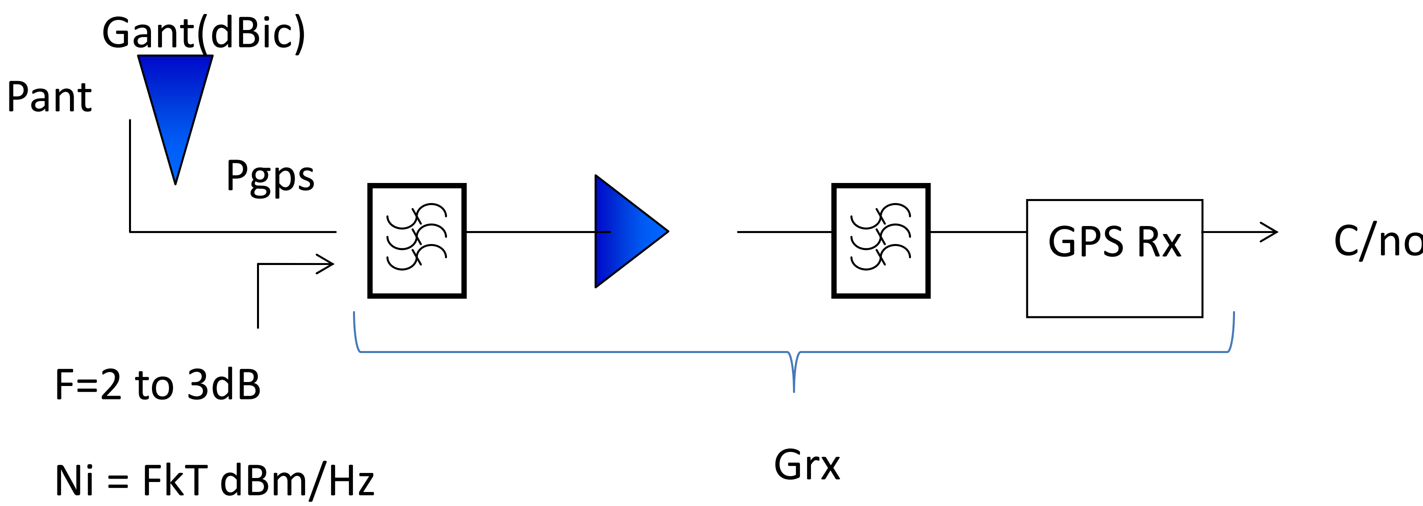
- Spirent 8100-A500 or 8100-A750 UMTS Location Test System (ULTS)
- Test Pack: TM-LBS-OTA

2.4.3 Radiated Tests (CDMA Devices)

- Spirent C2K-ATS Position Location Test System (PLTS)
- Test Pack: PLTS-OTA-01

Appendix II

In radiated (anechoic chamber) testing, the SV and blocker power levels at the antenna connector are estimate using the method described below.



From the Rx noise figure the noise spectral density at the output is

$$no = FkTG_{rx}$$

Allows the formation of the ratio with the signal at the output of the GPS Rx

$$\frac{C}{no} = \frac{P_{gps}G_{rx}}{FKTG_{rx}}$$

Note the GPS antenna gain is irrelevant. The Rx gain cancels leaving

$$\frac{C}{no} = \frac{P_{gps}}{FKT}$$

From which the Pgps can be calculated.

$$P_{gps} = (FKT)\left(\frac{C}{no}\right)$$

Surveying several Filter-LNA-Filter devices the F ranges from 2 to 3dB so if we use F=2.5dB we will have a reasonably accurate estimate of F.

The GPS chipset manufactures do not have a standard method of reporting the C/N_0, some include the noise figure and some do not. Since the noise figure is nominally 2.5dB we will adopt the position that assumes that the F is not included in the C/N_0 which will result in only a 2.5dB nominal error. This C/N_0 method (based on assuming that the C/N_0 is referenced to the DUT's antenna connector) is also in keeping with the C/N_0 tables reported in many of the standards as well.

In order to calibrate the power at the GPS transmit antenna in the anechoic chamber we will first establish the -130dBm level at the GPS Rx input by adjusting the GPS Tx level until the C/no =44dB-Hz. This represents the antenna noise of -174dBm/Hz and a signal level of -130dBm for a net C/no of 44dB-

Hz. Lower GPS levels are established by reducing the power at the transmit antenna of the anechoic chamber relative to the GPS Tx power at this level. We will not use C/N_0 at lower levels to establish GPS signal levels since the C/N_0 variation will increase with decreasing signal and C/N_0. We will also establish the LTE band 24 power by referencing it to the GPS power level at the anechoic chamber Tx antenna.

References

[1] 3GPP TS 34.171

[2] TIA-916

[3] CTIA v3.1

Appendix E

Detailed Test Plan
General Location / Navigation Sub-Group
Version 2.0
May 15, 2011

Introduction

The following detailed test plan describes the equipment, setup and methods for measuring the susceptibility of various GPS receivers to interference from LightSquared LTE transmitters operating in the Mobile Satellite Service (MSS) L-band. Any modifications to or deviations from this test plan must be approved by the members of the General Location / Navigation Sub-Group.

Test Equipment and Setup

Overview:

The general parameters for test are to provide an interfering set of signals at the LightSquared downlink and uplink frequencies in the presence of a controlled set of GPS signals. Figure 1 illustrates the basic test setup for testing interference from the LightSquared downlink.

All tests contained in this document shall be performed as radiated tests in an RF chamber. (Acceptable chambers include FCC-approved or equivalent RF anechoic or semi-anechoic chamber. Or, a GigaHertz Transverse Electromagnetic (GTEM) cell may be substituted for select tests with the approval of the sub-group.) The test lab shall calibrate the chamber with the understanding that all power references in this document are specified as radiated power (EIRP) incident on the DUT. It is not anticipated that the power level from the LightSquared downlink source at the receiver will be high enough to require additional isolation from the other sources. Also, if the test lab chooses to use computer-controlled RF switches (as indicated in the block diagram) to reduce test time, high quality mechanical RF switches rated for at least 18GHz shall be used (e.g. Agilent 44476A Microwave Multiplexer Module or equivalent).

In order to maintain consistency and ensure uniform product set-up between DUTs and manufacturers, all tests shall be run in accordance with ANSI C63.4. The FCC specifies ANSI C63.4 for all radiated tests.

Specific manufacturers and models of test equipment are mentioned throughout this document. These are provided for reference. The test lab may make equivalent equipment substitutions with approval from the General Navigation Sub-group.

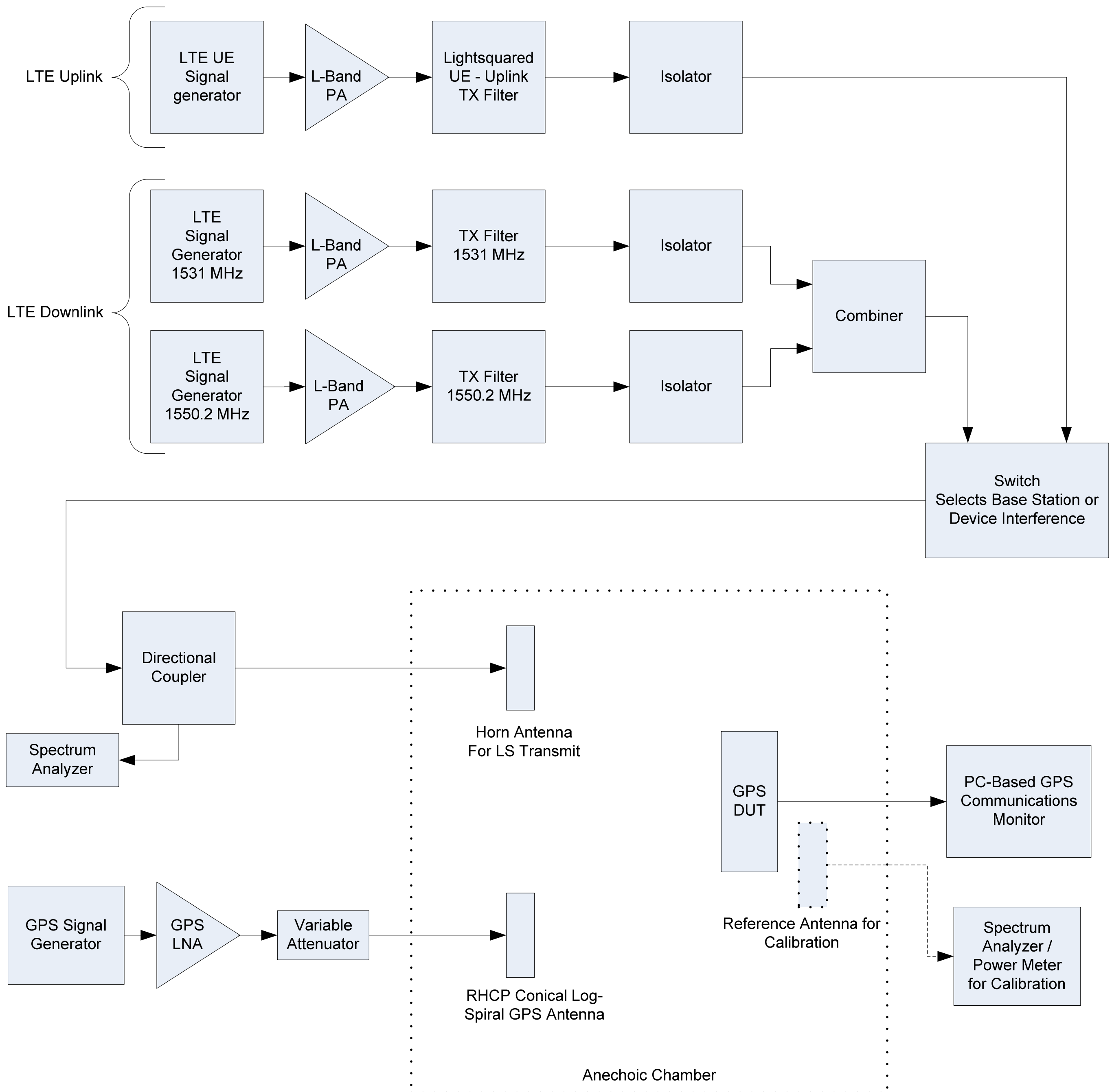


Figure 4 – Simplified Test Equipment Block Diagram: Radiated Immunity Tests

LightSquared Downlink Source:

Recommended Test Equipment

Equipment	Manufacturer	Model	QTY
Vector Signal Generator	Agilent	E4438C	2
Signal Studio for 3GPP LTE FDD	Agilent	N7624B	2
Amplifier	Amplifier Research	AR 50S1G4A	2
Band Pass Filter	RF Morecomm	RMC1531B10M01	1
	RF Morecomm	RMC1550B10M01	1
RF Isolator	MECA	CN 1.500	2
Power Combiner	MECA	H2N - 1.500V	1
Directional Coupler	Mini Circuits	ZGDC20-33HP	1
TX Antenna	ETS-Lindgren	3115	1

The test equipment recommended for simulating this source is listed in Table 1. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted).

Table 1: Test Equipment – LS Downlink

Test Equipment Setup

Two vector signal generators capable of producing LTE modulation shall be used to simulate the LightSquared downlink transmitters at 1531 MHz and 1550 MHz. The signal bandwidth shall either bet 5 MHz or 10 MHz depending on whether Phase 0, 1, or 2 signals are being tested. Table 2 provides the LTE signal setup parameters. The signals shall be amplified and filtered using the LightSquared provided transmit filters. The signals shall then be combined and fed to the transmit antenna. The transmit antenna shall be linearly polarized. During the Interference Susceptibility Test, either the Transmit Antenna or the DUT shall be rotated to find the angle of maximum susceptibility. This angle shall be documented for each DUT and used for the remainder of the tests.

Parameter	Setting	Comment
Center Frequency	1552.7 MHz	Phase 0
	1528.8 MHz & 1552.7 MHz	Phase 1
	1531 MHz and @ 1550.2 MHz	Phase 2
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Frame Duration	10 ms	
Sub frame Duration	1.0 ms	
Subcarrier Modulation	QPSK	For PCH , PDCCH, PDSCH
Subcarrier Size	15 KHz	
Channel Bandwidth	5 MHz	Phase 0 / 1
	10 MHz	Phase 2
PRB Bandwidth	0.180 MHz	
Sampling Rate	7.68 MHz	Phase 0 / 1
	15.36 MHz	Phase 2
FFT Size	512	Phase 0 / 1
	1024	Phase 2
Dummy Data	PN9	

Table 2: LTE Downlink Signal Setup Parameters

Calibration

The power of the sources shall be measured at the directional coupler as well as at the reference antenna in order to establish the losses due to the equipment setup. The net loss shall be documented in the test report. The reference antenna shall then be removed from the anechoic chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.

LightSquared Uplink Source:

Recommended Test Equipment

The test equipment recommended for simulating this source is listed in Table 3. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted).

Equipment	Manufacturer	Model	QTY
Vector Signal Generator	Rohde & Schwarz	CMU200A	1
Amplifier	Amplifier Research	AR 50S1G4A	1
Band Pass Filter	K&L Microwave	K&L 4CP120-1632.5/E10.3-0/0	2
	K&L Microwave	K&L 4CP120-1651.7/E10.3-0/0	2
RF Isolator	MECA	CN 1.500	2
Power Combiner	MECA	H2N - 1.500V	1
Directional Coupler	Mini Circuits	ZGDC20-33HP	1
TX Antenna, Horn	ETS-Lindgren	3115	1

Table 3: Test Equipment – LS Uplink

Test Equipment Setup

A vector signal generator capable of producing LTE modulation shall be used to simulate the LightSquared uplink transmitter. The low, middle, and high channel shall be simulated. Table 4 provides the LTE signal setup parameters. The signal shall be amplified and filtered using a LightSquared provided transmit filter. The signal shall then be fed to the transmit antenna. The transmit antenna shall be linearly polarized. During the Interference Susceptibility Test, either the TX Antenna or the DUT shall be rotated to find the angle of maximum susceptibility. This angle shall be documented for each DUT and used for the remainder of the tests.

Parameter	Setting	Comment
Center Frequency	1632.5 MHz	Low / Middle / High, according to test plan.
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM / OFDMA	
Allocation	1 Lower-most RB Freq. = 1628 - 1628.180 MHz	
RB Bandwidth	180 kHz	
UE Power	+23 dBm	
Subcarrier Modulation	QPSK	
Dummy Data	PN9	

Table 4: LTE Uplink Signal Setup Parameters

Calibration

The source power shall be measured at the directional coupler as well as at the reference antenna in order to establish the losses due to the equipment setup. The net loss shall be documented in the test report. The reference antenna shall then be removed from the chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.

GPS Simulator Source:

Recommended Test Equipment

The test equipment recommended for simulating this source is listed in Table 5. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted). *Reference power levels shall be determined in the chamber by assuming a 0 dBic RHCP reference antenna for the DUT.*

Equipment	Manufacturer	Model	QTY
Satellite Simulator	Spirent	GSS 6700*	1
Record Playback System	Spirent	GSS 6400*	1
Active GPS Patch Antenna for Live Test Recording	CTI	GPS-WP/UNI	1
GPS Transmit Antenna, RHCP Conical Log-Spiral	ETS-Lindgren	3102L	1
GPS Low Noise Amplifier	Mini-Circuits	ZHL-1217HLN	1
Step Attenuator	JFW Industries	50R-019-SMA	1
		50R-243	1
GPS Communications Monitor	Provided by DUT Manufacturer	N/A	1

** Substitutes are not allowed for this equipment.*

Table 5: Test Equipment – GPS Signals

Static Use Case Simulator Setup: *A Spirent GSS 6700 shall be used to simulate the following satellite signals under static conditions.*

Exactly 5 GPS satellites transmitting C/A code only

Highest elevation satellite at maximum power (-119.5 dBm) (per GPS SPS, including maximum satellite antenna gain- DO-229D 2.1.1.10)

Lowest elevation satellite at minimum power (-128.5 dBm) (per GPS SPS, including minimum satellite antenna gain - DO-229D 2.1.1.10)

The other three (3) satellites shall be 3 dB higher than the satellite at minimum power (-125.5 dBm)

HDOP range from 1.4 to 2.1

For the *Static Interference Susceptibility Tests* only (Sections IV.A. and IV.B.), the aforementioned Satellite signal power levels shall be amended so that all 5 satellites are transmitting at -128.5dBm.

Dynamic Use Case Simulator Setup: *A Spirent GSS 6700 shall be used to simulate the following satellite signals under dynamic conditions.*

Exactly 6 GPS satellites transmitting C/A code only
HDOP range from 1.4 to 2.1
Reference signal power for all satellites: -127 dBm
Trajectory Description: A rectangular trajectory with rounded corners similar to the trajectory described in section 5.6.4.1 of 3GPP TS 34.172 v10.0.0. This scenario is a rectangle 940m by 1440m with various linear acceleration and deceleration profiles and an angular acceleration of 2.4 m/s^2 in the turns.

Dynamic Use Case Record Playback System Setup: *Representative signals for each of the following scenarios shall be recorded using a Spirent GSS 6400 Record Playback System to ensure that the same scenario can be replayed consistently for all tests. A calibrated RHCP patch antenna shall be used to collect the data and shall be oriented in a manner consistent the use case being recorded, as specified below. Detailed instructions on recording live signals are included in Appendix 2 for reference.*

General Use Case 1: Suburban

The DUT is mounted on the dash of a vehicle which is moving in a suburban, tree lined environment. The DUT will experience frequent changes of direction, obscuration of signals by the roof of the car, and mild dynamics. This use case shall be recorded with a predetermined route specified by the sub-group.

General Use Case 2: Urban Canyon

The DUT is mounted on the dash of a vehicle which is moving in an urban canyon environment. The DUT will experience frequent changes of direction, obscuration of signals by the roof of the car, and mild dynamics. This use case shall be recorded in either Chicago, New York, or San Francisco. The sub-group shall make the final determination about the test location and define the specific test route.

Outdoor Use Case: Deep Forest

The DUT is held in the hand of a moving user while walking in a deep forest environment when leaves are on the trees. The DUT will experience some dynamics associated with walking. This use case shall be recorded with a predetermined route specified by the sub-group.

Fitness Use Case: Arm Swing Environment

The DUT is mounted on the arm of a user who is swinging his/her arms in a manner consistent with distance running. The DUT will experience frequent heading changes and the signal will be obscured by the body at times. Stressful dynamics are associated with the arm swing. This use case shall be recorded with a predetermined route specified by the sub-group.

Calibration

The source power shall be measured at the output of the GPS satellite simulator as well as at the reference antenna in order to establish the losses due to the equipment setup. Due to the low signal power in the GPS band, a Network Analyzer should be *substituted into the test setup and used for calibration. The net loss shall be documented in the test report. The Network Analyzer shall be removed from the setup. Likewise, the reference antenna shall then be removed from the anechoic chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.*

<u>Test Plan Summary</u>

The number of tests and configurations required for each DUT is quite large due to many variables and constraints that require investigation. There are several key test variations that substantially increase the total number of tests performed, and so these deserve special consideration. The sub-group believes that it is important to characterize and understand these variations; however, the extremely tight schedule under which we are operating precludes this possibility. Consequently, configurations for Phase 0 and Phase 2 LightSquared Downlink signals will not be applied to every test. These configurations will only be tested during the Interference Susceptibility test as indicated in Table 6. Further, testing of the interference from the LightSquared uplink (both stand-alone and in tandem with the downlink) will be a secondary priority to the downlink testing. Nevertheless, the uplink signals must be evaluated during the static susceptibility test at a minimum. Finally, the LightSquared transmit antenna polarization shall be evaluated in the horizontal and vertical polarizations only during the Interference Susceptibility test on a per-DUT basis. All subsequent tests on that particular DUT shall be run with the transmit antenna in the polarization that caused the worst performance. The sub-group realizes that omitting these test variations limits our ability to fully explore the effects of intermodulation and overload on the GPS receivers under test, but sees no other alternative given our time constraints.

The test matrices in Tables 6 and 7 provide a concise summary of the tests that can be run within the time constraints imposed on the group. Details relating to specific tests can be found in Sections IV and V. The members of the General Navigation sub-group, in conjunction with the test lab, may choose to omit some test cases for certain devices. Such decisions shall be based on test data indicating that a particular test does not yield useful data. Additionally, device manufacturers and the test lab may choose to omit certain tests based on the time and schedule constraints imposed upon the sub-team. The test lab shall note all deviations from the test plan in the final test report and shall also keep the General Location / Navigation Sub-Team apprised of any deviations on a weekly basis.

For reference, a complete list of devices to be tested can be found in Appendix 1.

		LightSquared Interference - Downlink			
		Phase 0 --> 5 MHz BW		Phase 1 --> 5 MHz	Phase 2 --> 10 MHz
	Test Item	1552.7 MHz	1528.8 MHz	1552.7 MHz 1528.8 MHz	1531 MHz 1550.2 MHz
Static Test Cases	Interference Susceptibility Test	X	X	X	X
Static Test Cases	Interference Susceptibility Test (Acquisition Sensitivity)	No Time	No Time	X	No Time
Static Test Cases	TTFF - Cold Start	No Time	No Time	X	No Time
Static Test Cases	TTFF - Warm Start	No Time	No Time	X	No Time
Static Test Cases	WAAS Demodulation Test - Cold Start to Differential Fix	No Time	No Time	X	No Time
Dynamic Test Cases	Simulated Position and Velocity Tests	No Time	No Time	X	No Time
Dynamic Test Cases	Naviation Position and Velocity Tests	No Time	No Time	X	No Time
Dynamic Test Cases	TTFF - Cold Start	No Time	No Time	X	No Time
Dynamic Test Cases	TTFF - Warm Start	No Time	No Time	X	No Time

Table 6: Test Matrix – Downlink Tests

		LightSquared Interference - Uplink			
		Phase 0/1 --> 5 MHz BW		Phase 2 --> 10 MHz BW	
	Test Item	1654.2 MHz	1630.3 MHz	1632.5 MHz	1651.7 MHz
Static Test Cases	Interference Susceptibility Test	No Time	If Time Permits	No Time	No Time
Static Test Cases	Interference Susceptibility Test (Acquisition Sensitivity)	No Time	If Time Permits	No Time	No Time
Static Test Cases	TTFF - Cold Start	No Time	If Time Permits	No Time	No Time
Static Test Cases	TTFF - Warm Start	No Time	If Time Permits	No Time	No Time
Static Test Cases	WAAS Demodulation Test - Cold Start to Differential Fix	No Time	If Time Permits	No Time	No Time
Dynamic Test Cases	Simulated Position and Velocity Tests	No Time	If Time Permits	No Time	No Time
Dynamic Test Cases	Naviation Position and Velocity Tests	No Time	If Time Permits	No Time	No Time
Dynamic Test Cases	TTFF - Cold Start	No Time	If Time Permits	No Time	No Time
Dynamic Test Cases	TTFF - Warm Start	No Time	If Time Permits	No Time	No Time

Table 7: Test Matrix – Uplink Tests

Static Tests

Interference Susceptibility Test

Test Setup: *The device under test (DUT) shall be exposed to modified test signals per Section II.D.2.f. Use a communications monitor (provided by manufacturer) to record the baseline C/N_0 reported by the GPS receiver.*

Measurement Parameters: *Measure and record interfering simulated LightSquared transmitter power levels that result in 1dB, 3dB, 6dB, 10dB, and 20dB degradations in average reported C/N_0, as well as a complete loss of fix.*

Key Performance Indicator (KPI): *Average C/N_0 Degradation from Baseline (dB-Hz)*

Interference Susceptibility Test (Acquisition Sensitivity)

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris) and restart the acquisition engine. Then iterate the GPS signal level to find the baseline Acquisition sensitivity (minimum level at which the receiver can acquire a GPS signal within 3 minutes) reported by the GPS receiver.*

Measurement Parameters: *Measure and record the acquisition sensitivities that result from the LightSquared transmitter power levels measured in Section 0, above. (Note, ephemeris must be deleted and the acquisition engine restarted prior to each iteration/trial).*

Key Performance Indicator (KPI): *Acquisition Sensitivity (dBm)*

TTFF (Time to First Fix) - Cold Start

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold Start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Measure and Record the TTFF's that result from the LightSquared transmitter power levels measured in Section IV.A.2. Also, record the average C/N_0 reported by the DUT after it has acquired a fix. (Any TTFF test that runs more than 3 minutes shall be aborted and the test operator shall note that the device failed to acquire a fix.)*

Key Performance Indicator (KPI): *TTFF (s)*

TTFF - Warm Start

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris) and restart the acquisition engine to simulate a* ***Warm start*** *condition. The command to warm start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Measure and Record the TTFF's that result from the LightSquared transmitter power levels measured in Section IV.A.2. Also, record the average* C/N_0 *reported by the DUT after it has acquired a fix. (Any TTFF test that runs more than 3 minutes shall be aborted and the test operator shall note that the device failed to acquire a fix.)*

Key Performance Indicator (KPI): *TTFF (s)*

WAAS Demodulation Test

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2 with the addition of a WAAS PRN and Signal in Space. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF of a Differential Fix over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Measure and Record the TTFF's that result from the LightSquared transmitter power levels measured in Section IV.A.2. Also, record the average* C/N_0 *reported by the DUT after it has acquired a fix. (Any TTFF test that runs more than 5 minutes shall be aborted and the test operator shall note that the device failed to acquire a fix.)*

TTFF – Differential (Time to First Differential Fix)
WAAS Satellite Bit Error Rate Degradation
(some receivers may not support this test)
Loss of Frame Synchronization - increase in age of differential correction
(some receivers may not support this test)
Average C/N_0 reported by the DUT
LightSquared Transmit Power Level

Key Performance Indicator (KPI): *TTFF - Differential*

Dynamic Tests

Simulated Position and Velocity Tests

***Test Setup**: The device under test (DUT) shall be exposed to simulated GPS signals per Section II.D.3. Use a communications monitor (provided by manufacturer) to measure and record the parameters detailed in the Measurement Parameters Section at 1 Hz intervals. Record baseline measurements without interference from the LightSquared transmitter.*

***Measurement Parameters:** Collect the following data (at 1Hz intervals) for each DUT in the presence of the LightSquared transmitter at the power levels measured in Section IV.A. Then record the deltas from the baseline measurements.*

Reported position including latitude, longitude, and altitude
Reported velocity
Reported Time
Reported C/N_0 for each satellite

***Key Performance Indicators (KPIs):** Position, Velocity, and Time (PVT) Error with respect to the truth as reported by the GPS satellite simulator, Average C/N_0 degradation.*

Navigation Position and Velocity Tests

***Test Setup**: The device under test (DUT) shall be exposed to pre-recorded test signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case, as indicated in* Appendix 1*. Use a communications monitor (provided by manufacturer) to measure and record the parameters detailed in the Measurement Parameters Section at 1 Hz intervals. Record baseline measurements without interference from the LightSquared transmitter.*

***Measurement Parameters:** Collect the following data (at 1Hz intervals) for each DUT in the presence of the LightSquared transmitter at the power levels measured in Section IV.A. Then record the deltas from the baseline measurements.*

Reported position including latitude, longitude, and altitude
Reported velocity
Reported Time
Reported C/N_0 for each satellite

***Key Performance Indicators (KPIs):** Position, Velocity, and Time (PVT) Error with respect to the baseline, Average C/N_0 degradation*

TTFF – Cold Start

Test Setup: *The device under test (DUT) shall be exposed to pre-recorded GPS signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case, as indicated in* Appendix 1*. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold Start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Measure and Record the TTFF's that result from the LightSquared transmitter power levels measured in Section IV.A.2. Also, record the average* C/N_0 *reported by the DUT after it has acquired a fix. (Any TTFF test that runs more than 3 minutes shall be aborted and the test operator shall note that the device failed to acquire a fix.)*

Key Performance Indicator (KPI): *TTFF (s)*

TTFF – Warm Start *(May need to skip this test due to time constraints)*

Test Setup*: The device under test (DUT) shall be exposed to pre-recorded GPS signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case, as indicated in* Appendix 1*. Use a communications monitor (provided by manufacturer) to delete ephemeris and restart the acquisition engine to simulate a* ***Warm Start*** *condition. The command to warm start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Measure and Record the TTFF's that result from the LightSquared transmitter power levels measured in Section IV.A.2. Also, record the average* C/N_0 *reported by the DUT after it has acquired a fix. (Any TTFF test that runs more than 3 minutes shall be aborted and the test operator shall note that the device failed to acquire a fix.)*

Key Performance Indicator (KPI): **TTFF (s)**

Appendix 1 to General Location/Navigation Test Plan

Device Under Test Assignments and Categorization

Device Category	Manufacturer	Model	Communications Monitor Specs			Static Test Cases					Dynamic Test Cases				
			Interface Capability	Manufacturer Support for Communications Monitor	Logging Capability Built into Unit	Interference Susceptibility Test	Interference Susceptibility Test (Acquisition Sensitivity)	TTFF - Cold Start	TTFF - Warm Start	WAAS Demodulation Test - Cold Start to Differential Fix	Simulated Position and Velocity Tests	Dynamic Use Case	Naviation Position and Velocity Tests	TTFF - Cold Start	TTFF - Warm Start
Fitness	Garmin	Forerunner 110	Y	Y	Y	Y	Y	Y	Y	N	Y	Fitness Use Case: Arm Swing Environment	Y	N	N
		Forerunner 305	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	N	N
		EDGE 500	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	N	N
		EDGE 800	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	N	N
Outdoor	Garmin	ETREX-H	Y	Y	Y	Y	Y	Y	Y	Y	Y	Outdoor Use Case: Deep Forest	Y	Y	Y
		Dakota 20	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
		Oregon 550	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
		GPSMAP 62	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
		Astro 220	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
		Rino 530HCx	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
Tracking	Garmin	GTU 10	Y	Y	N	Y	Y	Y	Y	N	Y	General Use Case 1: Suburban	Y	Y	Y
		DC40	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
	BI Incorporated	BI ExacuTrack® One	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
Marine	Garmin	GPS 17X (NMEA)	Y	Y	Y	Y	Y	Y	Y	Y	Y	None			
		GPSMAP 441	Y	Y	Y	Y	Y	Y	Y	Y	Y				
		GPSMAP 740	Y	Y	Y	Y	Y	Y	Y	Y	Y				
		GPSMAP 541	Y	Y	Y	Y	Y	Y	Y	Y	Y				
		GPSMAP 546	Y	Y	Y	Y	Y	Y	Y	Y	Y				
	Furuno	GP 33	Y	Y	N	Y	Y	Y	Y	Y	Y				
Automotive (in dash)	GM	OnStar Model TBD				Y	Y	Y	Y	N	Y	General Use Case 2: Urban Canyon	Y	Y	Y
	Garmin	GVN 54	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
PND	TomTom	XL335	Y	Y	N	Y	Y	Y	Y	N	Y	General Use Case 1: Suburban General Use Case 2: Urban Canyon	Y	Y	Y
		ONE 3RD Edition	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
		GO 2505	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
		VIA 1400/1405 or VIA 1500/1505	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
		XXL 530/530S or XXL 540/540S	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
		GO 720, GO 920	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
		GO 730, GO 930	Y	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
	Garmin	nűvi 2X5W	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		nűvi 13XX	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		nűvi 3XX	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		nűvi 37XX	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		Zumo 550	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		StreetPilot c330	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		zumo 220	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		nuvi 760	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
Fleet Management	Trimble	iLM2730 (with Mobile Mark Option J antenna)	Y	Y	N	Y	Y	Y	Y	Y	Y	General Use Case 1: Suburban General Use Case 2: Urban Canyon	Y	Y	Y
		TVG-850 (with Mobile Mark Option E glass-mount antenna)	Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y
		MTS521 (with CAT Shark Fin antenna)	Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y
		DCM300G (with Taoglas Combo antenna)	Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y
	e-Ride	Opus 5SD	Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y
First Responder Location	Motorola	APX7000	N	Y	N	Y	Y	Y	Y	N	Y	General Use Case 1: Suburban	Y	Y	Y
	Motorola	APX6000	N	Y	N	Y	Y	Y	Y	N	Y		Y	Y	Y
Emergency Vehicles (post-OEM mounted in vehicle)	Trimble	Placer Gold	Y	Y	N	Y	Y	Y	Y	Y	Y	General Use Case 2: Urban Canyon	Y	Y	Y
	Motorola	MW810	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		ML910	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		DMR / MotoTRBO	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
		External Antenna / LNA	Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y
Portable Aviation (non-TSO)	Garmin	GPSMAP 496	Y	Y	Y	Y	Y	Y	Y	Y	Y	None			
		aera® 5xx	Y	Y	Y	Y	Y	Y	Y	Y	Y				
		GPSMAP 696	Y	Y	Y	Y	Y	Y	Y	Y	Y				
	Honeywell Bendix/King	AV8OR	Y			Y	Y	Y	Y	Y	Y				

** NOTES **

1. The General Location/Navigation sub team initially selected devices based on market share and a design that is representative of those typically found in the category. Due to time constraints, not all devices will be tested. The sub team has sought to ensure that the devices tested represent a variety of use cases (e.g. public safety, navigation, recreation) and asked manufacturers to prioritize the devices offered for testing. The devices that have been omitted from testing are listed in gray. USGIC supports testing of all receivers identified to the Working Group as requiring testing. USGIC believes that the reduction of the number of devices/receivers to be tested, solely to meet schedule considerations, raises a concern about the completeness of the testing process.
2. The PND and Fleet Management device categories require testing in both the Suburban and Urban Canyon dynamic use cases. If time constraints prevent testing both use cases, the Urban Canyon use case shall be prioritized.

Appendix 2 to General Location/Navigation Test Plan

Procedure for Record and Playback of Live GPS Signals with the GSS6400 Spirent Record Playback System

I. Introduction

The purpose of this document is to define a set of test procedures and conditions for using the Spirent GSS6400 Record/Playback system to collect live GPS signals and replay them with high fidelity in a controlled laboratory environment.

This document will not detail the user interface specifics of the GSS6400 as it is assumed that the reader has some familiarity with this product. This document will refer only to the settings and functions of the GSS6400 that were used to record and validate via playback a GPS test scenario in a laboratory environment.

The overarching goal is to provide a GPS signal playback configuration that closely approximates in the laboratory the signal conditions that a GPS device under test would encounter if the testing were being conducted live on location in the field.

II. Setup for Recording Test Signals

A. GSS6400 Setup

1. *GSS6400 components:*
    - GSS6400 unit
    - GSS6400 external antenna (CTI, GPS-WP/UNI)
    - GSS6400 12V power cable (the internal battery provides approximately 40 minutes of runtime on a full charge)

2. *The GSS6400 shall use Software version 10.11.16 (or greater) and shall be preset to its default settings.*

3. ***Note** Please verify that the GSS6400 has sufficient disc space available for recording. 20GB for each hour of planned recording should be sufficient.*

B. Test Platform Setup

1. *Connect the GSS6400 to 12 volt vehicle power using the provide 12V power cable. (For Outdoor and Fitness use cases, ensure that the internal battery is charged.)*

2. *Connect the reference GPS antenna to the GSS6400 and position it according to the appropriate use case.*

   General Use Case 1 and 2, Urban / Suburban

   The GSS6400 GPS antenna shall be affixed to the center of the dash about 2 inches from the base of the windshield. The GSS6400 shall be placed on the seat or floorboard of the car.

   Outdoor Use Case (deep forest)

   The GSS6400 GPS antenna shall be affixed to a dummy DUT and held in the tester's hand while walking the test route. The GSS6400 shall be placed in a backpack worn by the tester.

   Fitness Use Case (Arm Swing Environment)

   The GSS6400 GPS antenna shall be affixed to a dummy DUT worn on the tester's wrist while jogging the test route. The GSS6400 shall be placed in a backpack worn by the tester.

3. *Secure GSS6400 unit, cables, and antenna so that they do not move during the test (except when required by test setup – e.g. Arm Swing Test).*

4. *Configure a reference GPS receiver in the same orientation as the GSS6400 antenna, maintaining a separation distance of at least 12". The Reference Receiver shall log data to be used to validate the recording and to calibrate the RF chamber for playback.*

C. Recording the Signals

1. Begin Logging

- Power on the GSS6400 and start a new recording.
- Power on the *Reference Receiver* and start logging.

2. Initial Acquisition

Begin each recording session by maintaining a stationary position and providing the GSS6400 Antenna and *Reference Receiver* with a clear, unobstructed view of the sky for 15 minutes.

3. Record the pre-planned test route

After the initial 15 minute acquisition period, continue recording and drive, walk, or run the prescribed test route.

4. Stop Recording and Save Data

Stop recording on the GSS 6400 and the *Reference Receiver* and save/archive the data files to an external storage medium to make room for subsequent recordings.

III. Test Environment Setup

The playback testing should be performed in a RF chamber as specified in Section II.D.4 of the Detailed Test Plan. The same GSS6400 used to make the recordings should be used for the validation and playback testing.

The GSS6400 settings should remain at default values for the validation and playback testing. Since the GSS6400 is designed to playback with the same signal strength that it received during the recording, the signal level is too low for playback in a radiated environment. Consequently, a low-noise amplifier (Mini-Circuits ZHL-1217HLN or similar) is recommended. Further, the signal level shall be adjusted using a post-LNA attenuator as the software attenuation feature on the GSS 6400 is unreliable.

IV. Validation of the Recording

Each recording should be validated as soon as possible to ensure there were no anomalies or errors introduced by the test equipment or test environment. Precise calibration of the GPS signal levels is not required at this point.

The *Reference Receiver* (for the use case in question) shall be mounted in the test chamber. Then use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Restart the acquisition engine to simulate a Cold Start condition, then enable logging. Once logging has commenced, start the playback of the GPS recording and verify that the *Reference Receiver* acquires a 3D fix.

At the completion of the playback, stop the logging on the Reference Receiver. Using the log files from the playback and from the live recording, plot and compare the reported positions. The two position plots should be substantially the same – this validates that the GPS recording is good to use. If large discrepancies are observed (e.g. very large position jumps or large gaps in the logged position data), the recorded data may be corrupt.

V. Calibrating the EMI Chamber Playback Configuration

The flow chart in Figure B1 shows the process of calibrating the re-radiated GPS signal with the *Reference Receiver* used during the recording process.

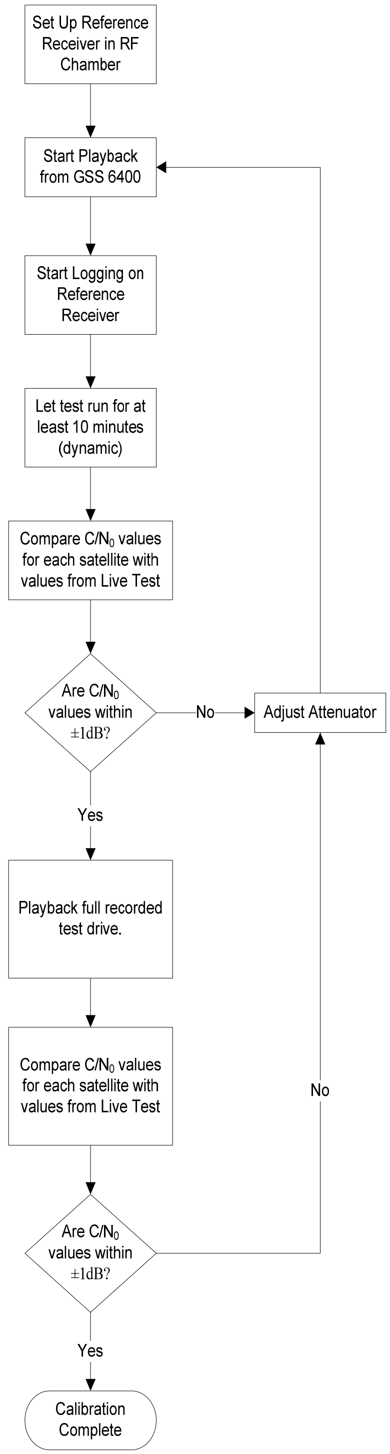


Figure B1: Process for Calibrating Recorded, Re-radiated GPS Signals

Appendix 3 to General Location/Navigation Test Plan

Test Routes for Dynamic GPS Testing

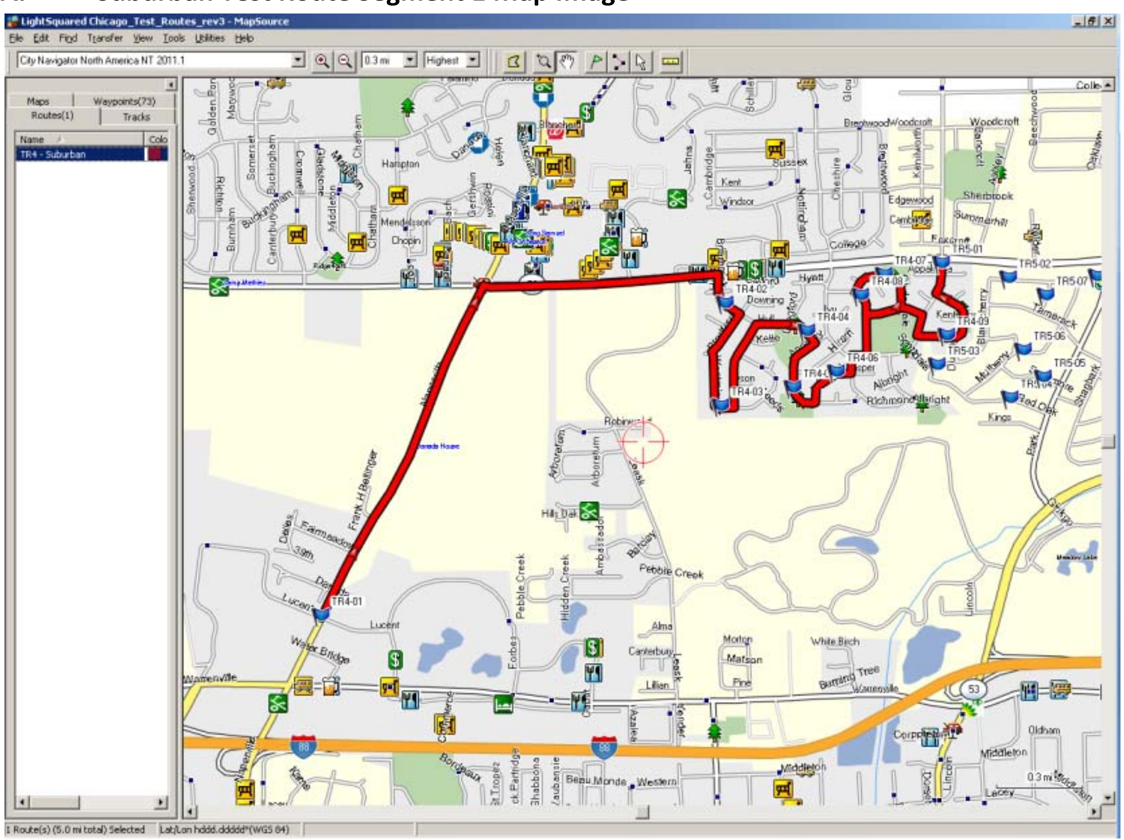
I. Introduction

Appendix 3 details the test routes to be used for recording dynamic GPS data for playback testing in the lab. Coordinates are provided in the WGS-84 reference system.
There are four general use cases called out in the test plan: General Navigation Use Case 1 (Suburban),General Navigation Use Case 2 (Urban Canyon), Outdoor Use Case (Deep Forest), and Fitness Use Case (Arm Swing). The test routes for each of these use cases are provided below. Any deviations from the prescribed routes (due to construction or road closures, for example) shall be noted in the final test report.

II. General Navigation Test Case #1 (Suburban)

The suburban test routes consist of 3 contiguous test route segments through tree lined streets in residential neighborhoods.

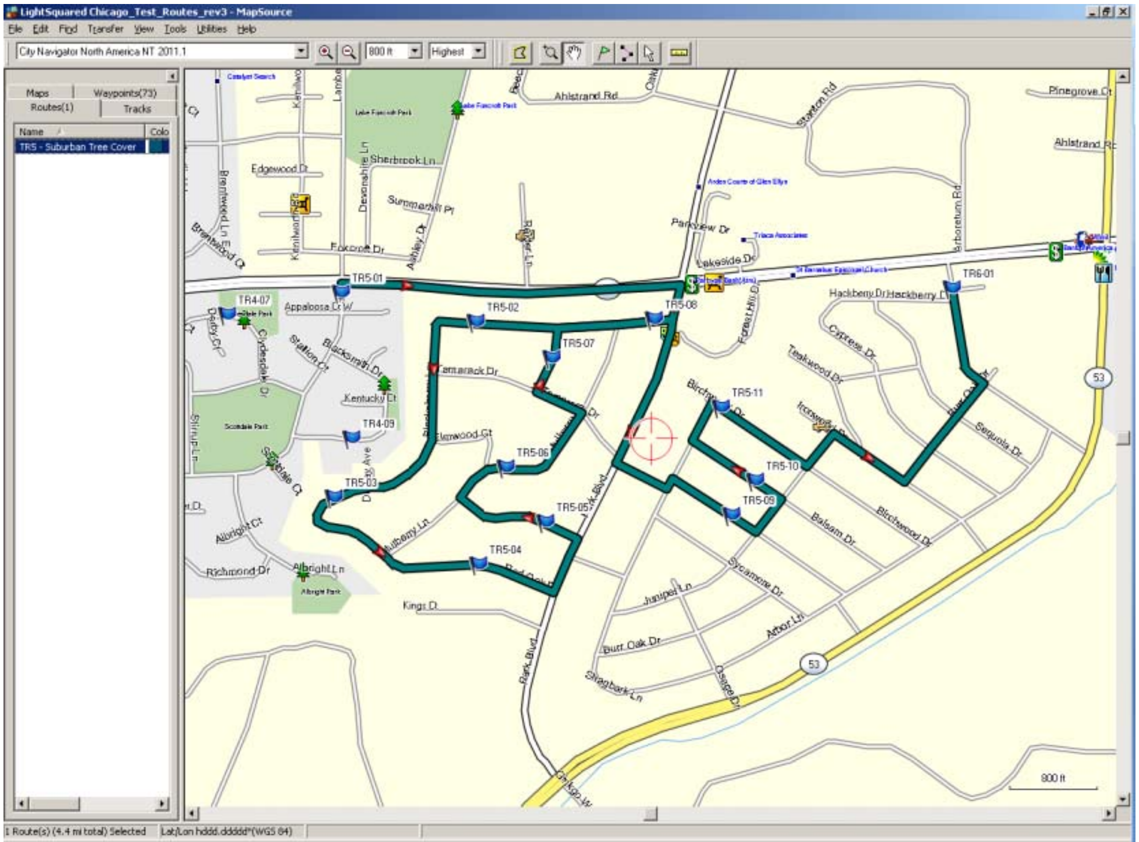
A. Suburban Test Route Segment 1 Map Image



B. Suburban Test Route Segment 1 Driving Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR4-01	0 ft		N41.81229 W88.11524
2	Get on Naperville Rd and drive northeast	0 ft	0 ft	N41.81229 W88.11524
3	Turn right onto Butterfield Rd	1.3 mi	1.3 mi	N41.82886 W88.10537
4	Turn right onto S Hull Dr	2.0 mi	0.7 mi	N41.82941 W88.09108
5	TR4-02	2.1 mi	0.1 mi	N41.82788 W88.09062
6	Get on S Hull Dr and drive southeast	2.1 mi	0 ft	N41.82788 W88.09062
7	Turn right onto S Bradford Dr	2.2 mi	285 ft	N41.82744 W88.08975
8	Turn left onto Westminster St	2.3 mi	0.2 mi	N41.82555 W88.09147
9	Turn left onto Durham Dr	2.5 mi	0.2 mi	N41.82285 W88.09130
10	TR4-03	2.5 mi	133 ft	N41.82273 W88.09088
11	Get on Durham Dr and drive east	2.5 mi	0 ft	N41.82273 W88.09088
12	Turn left onto Kingston Dr	2.6 mi	214 ft	N41.82276 W88.09010
13	Turn right onto E Hull Dr	2.9 mi	0.3 mi	N41.82693 W88.08877
14	TR4-04	3.1 mi	0.2 mi	N41.82647 W88.08567
15	Get on E Hull Dr and drive southeast	3.1 mi	0 ft	N41.82647 W88.08567
16	Turn right onto Appleby Dr	3.1 mi	227 ft	N41.82598 W88.08516
17	TR4-05	3.3 mi	0.2 mi	N41.82367 W88.08649
18	Get on Appleby Dr and drive south	3.3 mi	0 ft	N41.82367 W88.08649
19	Turn left onto Jasper Dr	3.4 mi	502 ft	N41.82302 W88.08516
20	TR4-06	3.5 mi	0.1 mi	N41.82445 W88.08385
21	Get on Jasper Dr and drive east	3.5 mi	0 ft	N41.82445 W88.08385
22	Turn left onto Richmond Dr	3.6 mi	240 ft	N41.82448 W88.08297
23	Turn right onto Scottdale Cir	3.6 mi	329 ft	N41.82538 W88.08297
24	Turn left onto Stirrup Ln	3.7 mi	257 ft	N41.82538 W88.08203
25	Turn right onto Shetland Dr	3.8 mi	0.1 mi	N41.82740 W88.08207
26	Turn left onto Clydesdale Dr	3.9 mi	0.1 mi	N41.82774 W88.07992
27	TR4-07	4.1 mi	0.1 mi	N41.82931 W88.08094
28	Get on Clydesdale Dr and drive west	4.1 mi	0 ft	N41.82931 W88.08094
29	Turn left onto Stirrup Ln	4.2 mi	0.1 mi	N41.82851 W88.08276
30	TR4-08	4.2 mi	136 ft	N41.82827 W88.08238
31	Get on Stirrup Ln and drive southeast	4.2 mi	0 ft	N41.82827 W88.08238
32	Turn left onto Shetland Dr	4.3 mi	350 ft	N41.82740 W88.08207
33	Turn right onto Scottdale Cir	4.5 mi	0.2 mi	N41.82740 W88.07864
34	Turn left onto Blacksmith Dr	4.5 mi	388 ft	N41.82637 W88.07898
35	TR4-09	4.6 mi	503 ft	N41.82624 W88.07715
36	Get on Blacksmith Dr and drive east	4.6 mi	0 ft	N41.82624 W88.07715
37	Turn right onto Scottdale Cir	4.9 mi	0.2 mi	N41.82847 W88.07782
38	TR4-10	5.0 mi	526 ft	N41.82986 W88.07748

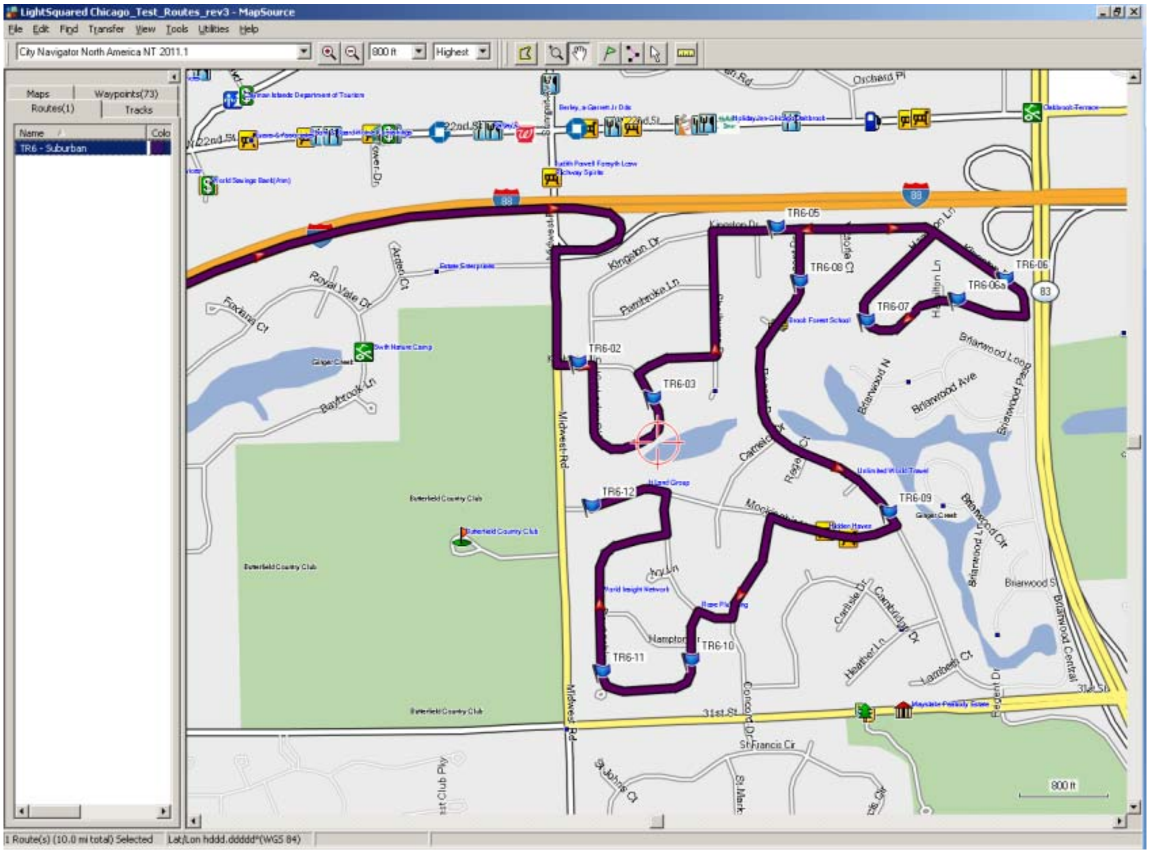
C. Suburban Test Route Segment 2 Map Image



D. Suburban Test Route Segment 2 Driving Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR5-01	0 ft		N41.82986 W88.07748
2	Get on Scottdale Cir and drive north	0 ft	0 ft	N41.82986 W88.07748
3	Turn right onto Butterfield Rd	103 ft	103 ft	N41.83014 W88.07748
4	Turn right onto Park Blvd	0.6 mi	0.5 mi	N41.83010 W88.06718
5	Turn right onto Hackberry Dr	0.6 mi	321 ft	N41.82924 W88.06744
6	TR5-02	0.9 mi	0.3 mi	N41.82914 W88.07339
7	Get on Hackberry Dr and drive west	0.9 mi	0 ft	N41.82914 W88.07339
8	Turn left onto Blackcherry Ln	1.0 mi	307 ft	N41.82920 W88.07452
9	TR5-03	1.4 mi	0.4 mi	N41.82477 W88.07770
10	Get on Blackcherry Ln and drive southwest	1.4 mi	0 ft	N41.82477 W88.07770
11	Turn left onto Red Oak Dr	1.4 mi	270 ft	N41.82422 W88.07821
12	TR5-04	1.7 mi	0.3 mi	N41.82313 W88.07330
13	Get on Red Oak Dr and drive east	1.7 mi	0 ft	N41.82313 W88.07330
14	Turn left onto Park Blvd	1.8 mi	0.1 mi	N41.82246 W88.07104
15	Turn left onto Sycamore Dr	1.9 mi	525 ft	N41.82379 W88.07031
16	TR5-05	2.0 mi	297 ft	N41.82416 W88.07128
17	Get on Sycamore Dr and drive northwest	2.0 mi	0 ft	N41.82416 W88.07128
18	Turn right onto Mulberry Ln	2.1 mi	0.1 mi	N41.82482 W88.07387
19	TR5-06	2.2 mi	500 ft	N41.82552 W88.07247
20	Get on Mulberry Ln and drive east	2.2 mi	0 ft	N41.82552 W88.07247
21	Turn left onto S Tamarack Dr	2.4 mi	0.2 mi	N41.82693 W88.07018
22	Turn right onto Butternut Ln	2.5 mi	418 ft	N41.82744 W88.07156
23	TR5-07	2.5 mi	317 ft	N41.82824 W88.07109
24	Get on Butternut Ln and drive northeast	2.5 mi	0 ft	N41.82824 W88.07109
25	Turn right onto Hackberry Dr	2.6 mi	296 ft	N41.82903 W88.07091
26	TR5-08	2.8 mi	0.2 mi	N41.82920 W88.06798
27	Get on Hackberry Dr and drive east	2.8 mi	0 ft	N41.82920 W88.06798
28	Turn right onto Park Blvd	2.8 mi	148 ft	N41.82924 W88.06744
29	Turn left onto Tamarack Dr	3.0 mi	0.3 mi	N41.82568 W88.06915
30	Turn left onto Shagbark Ln	3.1 mi	482 ft	N41.82504 W88.06761
31	Turn right onto Tamarack Dr	3.2 mi	105 ft	N41.82529 W88.06744
32	TR5-09	3.3 mi	0.1 mi	N41.82434 W88.06562
33	Get on Tamarack Dr and drive southeast	3.3 mi	0 ft	N41.82434 W88.06562
34	Turn left onto Juniper Ln	3.3 mi	238 ft	N41.82396 W88.06490
35	Turn left onto Balsam Dr	3.4 mi	365 ft	N41.82478 W88.06413
36	TR5-10	3.4 mi	257 ft	N41.82519 W88.06490
37	Get on Balsam Dr and drive northwest	3.4 mi	0 ft	N41.82519 W88.06490
38	Turn right onto Shagbark Ln	3.6 mi	0.1 mi	N41.82624 W88.06684
39	Turn right onto Birchwood Dr	3.6 mi	382 ft	N41.82718 W88.06623
40	TR5-11	3.6 mi	100 ft	N41.82702 W88.06594
41	Get on Birchwood Dr and drive southeast	3.6 mi	0 ft	N41.82702 W88.06594
42	Turn left onto Juniper Ln	3.8 mi	0.2 mi	N41.82559 W88.06336
43	Turn right onto Ironwood Dr	3.9 mi	371 ft	N41.82641 W88.06254
44	Turn left onto Burr Oak Dr	4.0 mi	0.1 mi	N41.82521 W88.06040
45	Turn left onto Arboretum Rd	4.2 mi	0.2 mi	N41.82765 W88.05799
46	TR5-12	4.4 mi	0.2 mi	N41.82997 W88.05894

E. Suburban Test Route Segment 3 Map Image

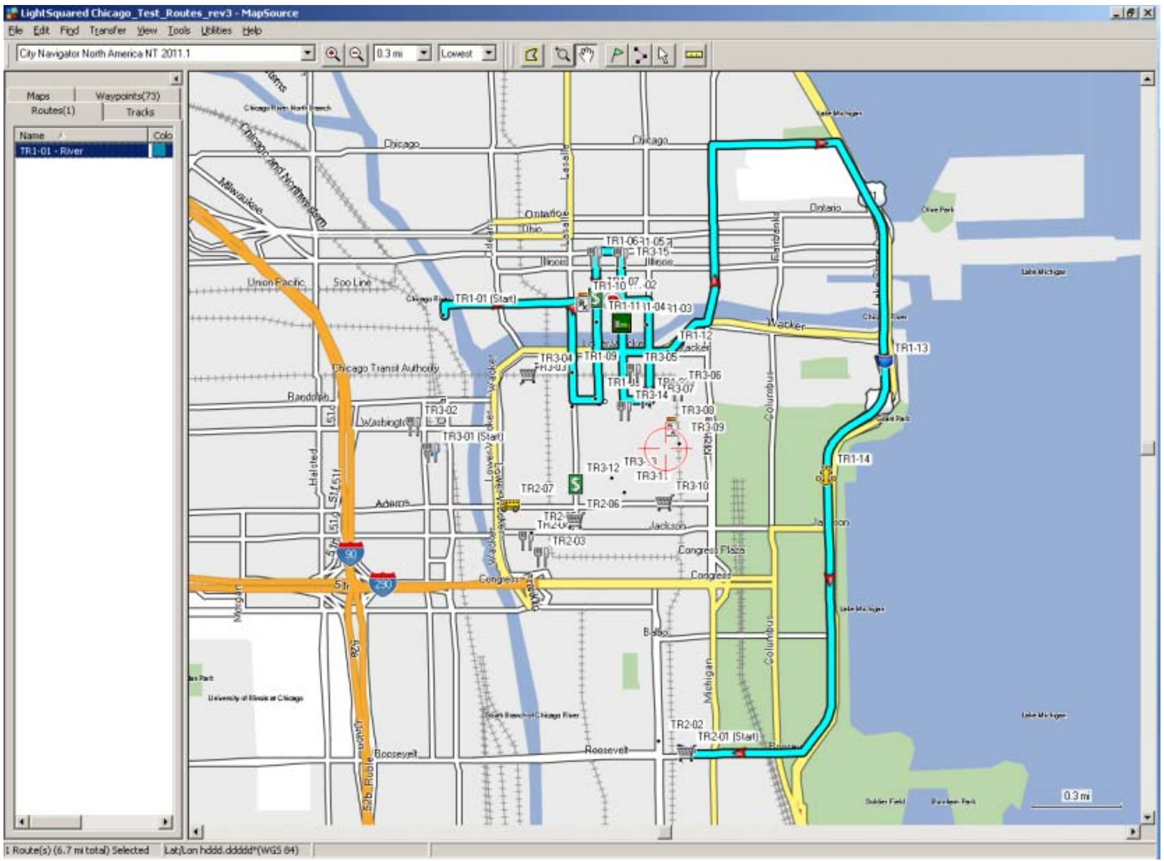


F. Suburban Test Route Segment 3 Driving Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR6-01	0 ft		N41.82997 W88.05894
2	Get on Arboretum Rd and drive north	0 ft	0 ft	N41.82997 W88.05894
3	Turn right onto Butterfield Rd	271 ft	271 ft	N41.83070 W88.05911
4	Take the I-355 S ramp to the right towards Jolie	1.5 mi	1.5 mi	N41.83280 W88.03049
5	Take the I-88 E/I-88 W ramp to the right toward	1.9 mi	0.4 mi	N41.82740 W88.02886
6	Take the I-88 E ramp to the left towards Chicag	2.1 mi	0.2 mi	N41.82435 W88.02898
7	Keep left onto I-88 E	4.1 mi	2.0 mi	N41.83619 W88.00087
8	Take the Midwest Rd ramp to the right	5.7 mi	1.6 mi	N41.84431 W87.97165
9	Turn left onto Midwest Rd	5.9 mi	0.2 mi	N41.84328 W87.97225
10	Turn left onto Kimberley Ln	6.1 mi	0.2 mi	N41.84044 W87.97221
11	TR6-02	6.2 mi	174 ft	N41.84044 W87.97157
12	Get on Kimberley Ln and drive east	6.2 mi	0 ft	N41.84044 W87.97157
13	Turn right onto Kimberley Cir	6.2 mi	118 ft	N41.84044 W87.97113
14	TR6-03	6.5 mi	0.3 mi	N41.83957 W87.96932
15	Get on Kimberley Cir and drive northwest	6.5 mi	0 ft	N41.83957 W87.96932
16	Turn right onto Charleton Pl	6.5 mi	268 ft	N41.84023 W87.96976
17	Turn left onto Shelburne Dr	6.7 mi	0.1 mi	N41.84066 W87.96744
18	Turn right onto Kingston Dr	6.9 mi	0.2 mi	N41.84375 W87.96753
19	TR6-05	7.0 mi	521 ft	N41.84377 W87.96561
20	Get on Kingston Dr and drive east	7.0 mi	0 ft	N41.84377 W87.96561
21	TR6-06	7.4 mi	0.4 mi	N41.84252 W87.95873
22	Get on Kingston Dr and drive southeast	7.4 mi	0 ft	N41.84252 W87.95873
23	Turn right onto Hamilton Ln	7.4 mi	387 ft	N41.84165 W87.95813
24	TR6-06a	7.5 mi	0.1 mi	N41.84201 W87.96017
25	Get on Hamilton Ln and drive west	7.5 mi	0 ft	N41.84201 W87.96017
26	TR6-07	7.7 mi	0.2 mi	N41.84149 W87.96290
27	Get on Hamilton Ln and drive northwest	7.7 mi	0 ft	N41.84148 W87.96290
28	Turn left onto Kingston Dr	7.9 mi	0.2 mi	N41.84371 W87.96083
29	Turn left onto Regent Dr	8.1 mi	0.2 mi	N41.84379 W87.96491
30	TR6-08	8.2 mi	495 ft	N41.84243 W87.96491
31	Get on Regent Dr and drive south	8.2 mi	0 ft	N41.84243 W87.96491
32	TR6-09	8.7 mi	0.5 mi	N41.83677 W87.96222
33	Get on Regent Dr and drive southeast	8.7 mi	0 ft	N41.83677 W87.96222
34	Turn right onto Mockingbird Ln	8.7 mi	117 ft	N41.83650 W87.96199
35	Turn left onto Concord Dr	8.9 mi	0.2 mi	N41.83671 W87.96577
36	Turn right onto Ivy Ln	9.1 mi	0.2 mi	N41.83422 W87.96693
37	Turn left onto Devonshire Dr	9.2 mi	294 ft	N41.83439 W87.96796
38	TR6-10	9.3 mi	475 ft	N41.83312 W87.96817
39	Get on Devonshire Dr and drive south	9.3 mi	0 ft	N41.83312 W87.96817
40	TR6-11	9.4 mi	0.2 mi	N41.83286 W87.97085
41	Get on Devonshire Dr and drive north	9.4 mi	0 ft	N41.83286 W87.97085
42	Turn left onto Ivy Ln	9.8 mi	0.3 mi	N41.83628 W87.96890
43	Turn left onto Mockingbird Ln	9.8 mi	379 ft	N41.83731 W87.96890
44	TR6-12	10.0 mi	0.1 mi	N41.83693 W87.97116

III. General Navigation Test Case #2 (Urban Canyon)

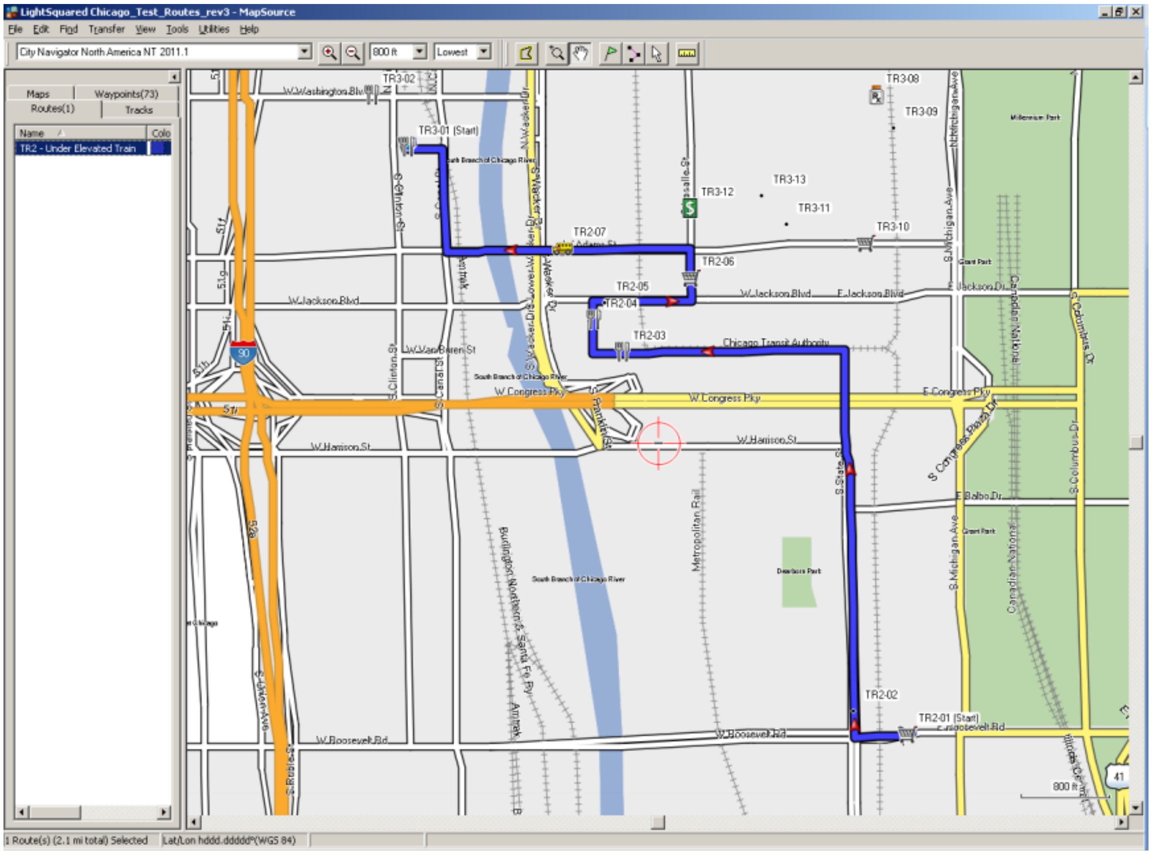
A. Urban Canyon Test Route Segment 1 Map Image



B. Urban Canyon Test Route Segment 1 Driving Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR1-01 (Start)	0 ft		N41.88855 W87.63997
2	Get on N Canal St and drive north	0 ft	0 ft	N41.88855 W87.63997
3	Turn right onto W Kinzie St	188 ft	188 ft	N41.88907 W87.64000
4	TR1-02	0.5 mi	0.5 mi	N41.88920 W87.63009
5	Get on W Kinzie St and drive east	0.6 mi	10 ft	N41.88922 W87.63009
6	Turn right onto N State St	0.7 mi	0.1 mi	N41.88928 W87.62803
7	TR1-03	0.7 mi	451 ft	N41.88808 W87.62803
8	Get on N State St and drive south	0.7 mi	12 ft	N41.88808 W87.62798
9	Turn right onto W Randolph St	1.0 mi	0.2 mi	N41.88447 W87.62790
10	TR1-03a	1.0 mi	74 ft	N41.88452 W87.62811
11	Get on W Randolph St and drive west	1.0 mi	16 ft	N41.88447 W87.62811
12	Turn right onto N Dearborn St	1.1 mi	362 ft	N41.88447 W87.62944
13	TR1-04	1.3 mi	0.3 mi	N41.88817 W87.62953
14	Get on N Dearborn St and drive north	1.3 mi	3 ft	N41.88817 W87.62954
15	TR1-05	1.6 mi	0.2 mi	N41.89130 W87.62961
16	Get on N Dearborn St and drive north	1.6 mi	7 ft	N41.89130 W87.62964
17	Turn left onto W Grand Ave	1.6 mi	126 ft	N41.89164 W87.62966
18	Turn left onto N Clark St	1.7 mi	397 ft	N41.89164 W87.63112
19	TR1-06	1.7 mi	125 ft	N41.89134 W87.63116
20	Get on N Clark St and drive south	1.7 mi	16 ft	N41.89134 W87.63110
21	TR1-07	1.8 mi	0.1 mi	N41.88937 W87.63107
22	Get on N Clark St and drive south	1.8 mi	9 ft	N41.88937 W87.63104
23	Turn right onto W Randolph St	2.2 mi	0.3 mi	N41.88447 W87.63090
24	TR1-08	2.2 mi	51 ft	N41.88452 W87.63103
25	Get on W Randolph St and drive west	2.2 mi	16 ft	N41.88447 W87.63103
26	Turn right onto N Lasalle St	2.2 mi	373 ft	N41.88447 W87.63240
27	TR1-09	2.3 mi	482 ft	N41.88576 W87.63240
28	Get on N Lasalle St and drive north	2.3 mi	12 ft	N41.88576 W87.63245
29	Turn right onto W Kinzie St	2.6 mi	0.2 mi	N41.88920 W87.63253
30	TR1-10	2.6 mi	191 ft	N41.88915 W87.63189
31	Get on W Kinzie St and drive east	2.6 mi	16 ft	N41.88920 W87.63189
32	Turn right onto N Clark St	2.7 mi	233 ft	N41.88920 W87.63103
33	TR1-11	2.7 mi	372 ft	N41.88821 W87.63099
34	Get on N Clark St and drive south	2.7 mi	12 ft	N41.88821 W87.63103
35	Turn left onto W Wacker Dr	2.8 mi	0.1 mi	N41.88675 W87.63099
36	TR1-12	3.0 mi	0.2 mi	N41.88679 W87.62682
37	Get on E Wacker Dr and drive east	3.1 mi	14 ft	N41.88683 W87.62683
38	Turn left onto N Upper Michigan Ave	3.2 mi	0.2 mi	N41.88821 W87.62455
39	Turn right onto E Chicago Ave	3.8 mi	0.6 mi	N41.89675 W87.62425
40	Turn right onto US 41 S	4.2 mi	0.4 mi	N41.89688 W87.61687
41	TR1-13	5.0 mi	0.8 mi	N41.88617 W87.61412
42	Get on N Lake Shore Dr and drive south	5.0 mi	0 ft	N41.88617 W87.61412
43	TR1-14	5.4 mi	0.4 mi	N41.88083 W87.61751
44	Get on S Lake Shore Dr and drive south	5.4 mi	2 ft	N41.88083 W87.61750
45	Turn right onto E Roosevelt Rd	6.3 mi	0.9 mi	N41.86752 W87.61893
46	TR1-15	6.7 mi	0.4 mi	N41.86744 W87.62575

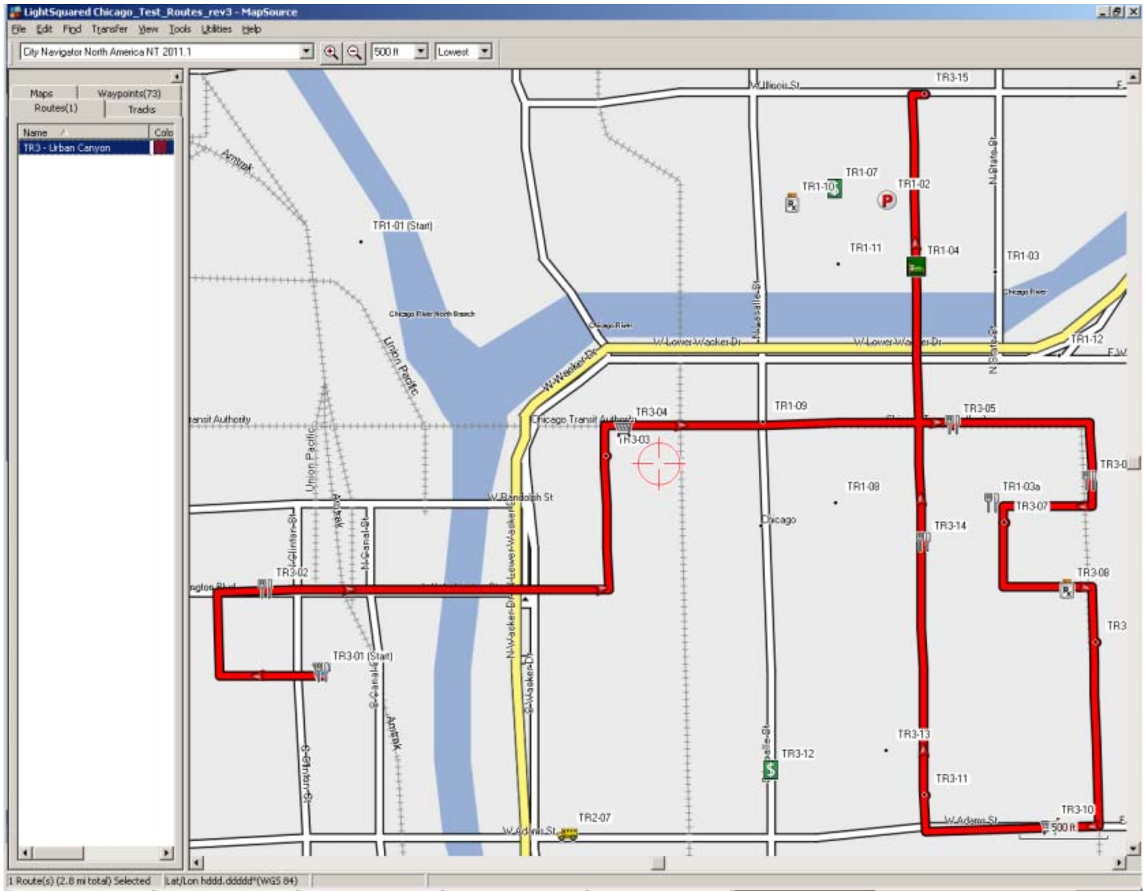
C. Urban Canyon Test Route Segment 2 Map Image



D. Urban Canyon Test Route Segment 2 Driving Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR2-01 (Start)	0 ft		N41.86748 W87.62575
2	Get on E Roosevelt Rd and drive west	16 ft	16 ft	N41.86744 W87.62575
3	Turn right onto S State St	448 ft	432 ft	N41.86739 W87.62734
4	TR2-02	0.1 mi	239 ft	N41.86804 W87.62734
5	Get on S State St and drive north	0.1 mi	4 ft	N41.86804 W87.62735
6	Turn left onto W Van Buren St	0.7 mi	0.6 mi	N41.87692 W87.62764
7	TR2-03	1.1 mi	0.3 mi	N41.87688 W87.63429
8	Get on W Van Buren St and drive west	1.1 mi	16 ft	N41.87684 W87.63429
9	Turn right onto S Franklin St	1.1 mi	245 ft	N41.87684 W87.63519
10	TR2-04	1.2 mi	309 ft	N41.87765 W87.63515
11	Get on S Franklin St and drive north	1.2 mi	12 ft	N41.87765 W87.63519
12	Turn right onto W Jackson Blvd	1.2 mi	172 ft	N41.87812 W87.63519
13	TR2-05	1.3 mi	121 ft	N41.87808 W87.63481
14	Get on W Jackson Blvd and drive east	1.3 mi	16 ft	N41.87812 W87.63481
15	Turn left onto S Lasalle St	1.4 mi	0.1 mi	N41.87812 W87.63223
16	TR2-06	1.4 mi	213 ft	N41.87868 W87.63223
17	Get on S Lasalle St and drive north	1.4 mi	9 ft	N41.87868 W87.63227
18	Turn left onto W Adams St	1.5 mi	267 ft	N41.87941 W87.63227
19	TR2-07	1.7 mi	0.2 mi	N41.87941 W87.63609
20	Get on W Adams St and drive west	1.7 mi	16 ft	N41.87937 W87.63609
21	Turn right onto S Canal St	1.9 mi	0.2 mi	N41.87932 W87.63957
22	Turn left onto W Madison St	2.0 mi	0.2 mi	N41.88186 W87.63970
23	TR2-08	2.1 mi	296 ft	N41.88190 W87.64073

E. Urban Canyon Test Route Segment 3 Map Image



F. Urban Canyon Test Route Segment 3 Driving Directions

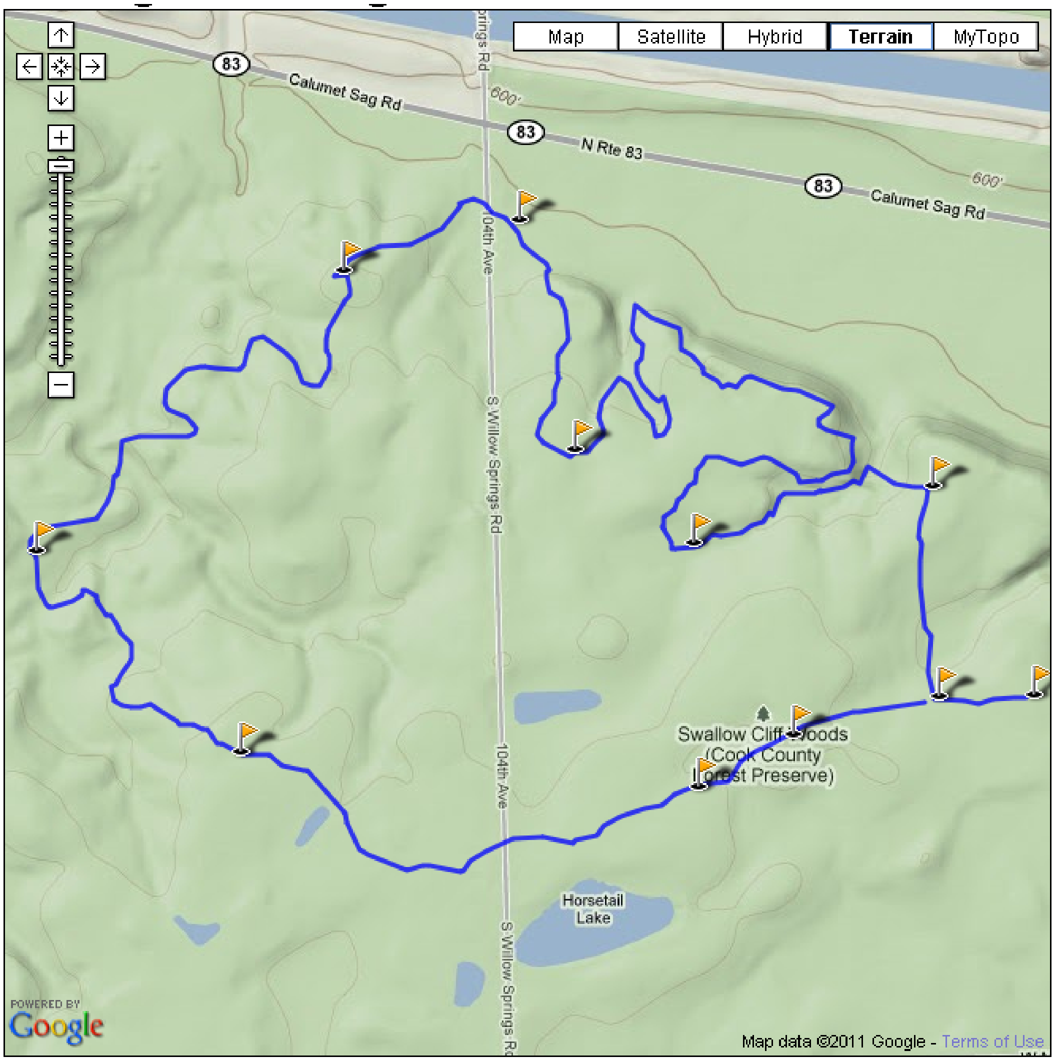
	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR3-01 (Start)	0 ft		N41.88190 W87.64073
2	Get on W Madison St and drive west	16 ft	16 ft	N41.88186 W87.64073
3	Turn right onto N Jefferson St	0.1 mi	525 ft	N41.88186 W87.64266
4	Turn right onto W Washington Blvd	0.2 mi	470 ft	N41.88314 W87.64270
5	TR3-02	0.2 mi	252 ft	N41.88319 W87.64180
6	Get on W Washington Blvd and drive east	0.2 mi	6 ft	N41.88317 W87.64180
7	Turn left onto N Franklin St	0.6 mi	0.3 mi	N41.88319 W87.63532
8	TR3-03	0.7 mi	0.1 mi	N41.88525 W87.63536
9	Get on N Franklin St and drive north	0.7 mi	12 ft	N41.88525 W87.63541
10	Turn right onto W Lake St	0.8 mi	172 ft	N41.88572 W87.63541
11	TR3-04	0.8 mi	121 ft	N41.88568 W87.63502
12	Get on W Lake St and drive east	0.8 mi	16 ft	N41.88572 W87.63502
13	TR3-05	1.1 mi	0.3 mi	N41.88572 W87.62884
14	Get on W Lake St and drive east	1.1 mi	16 ft	N41.88576 W87.62884
15	Turn right onto N Wabash Ave	1.2 mi	0.1 mi	N41.88576 W87.62627
16	TR3-06	1.3 mi	341 ft	N41.88486 W87.62627
17	Get on N Wabash Ave and drive south	1.3 mi	12 ft	N41.88486 W87.62622
18	Turn right onto E Randolph St	1.3 mi	141 ft	N41.88447 W87.62622
19	Turn left onto N State St	1.4 mi	455 ft	N41.88447 W87.62790
20	TR3-07	1.4 mi	106 ft	N41.88422 W87.62785
21	Get on N State St and drive south	1.4 mi	12 ft	N41.88422 W87.62790
22	Turn left onto E Washington St	1.5 mi	360 ft	N41.88323 W87.62790
23	TR3-08	1.6 mi	342 ft	N41.88319 W87.62670
24	Get on E Washington St and drive east	1.6 mi	16 ft	N41.88323 W87.62670
25	Turn right onto N Wabash Ave	1.6 mi	128 ft	N41.88323 W87.62622
26	TR3-09	1.7 mi	329 ft	N41.88237 W87.62614
27	Get on N Wabash Ave and drive south	1.7 mi	15 ft	N41.88237 W87.62619
28	Turn right onto E Adams St	1.9 mi	0.2 mi	N41.87954 W87.62609
29	TR3-10	1.9 mi	254 ft	N41.87954 W87.62700
30	Get on E Adams St and drive west	1.9 mi	9 ft	N41.87952 W87.62699
31	Turn right onto S Dearborn St	2.0 mi	0.1 mi	N41.87945 W87.62936
32	TR3-11	2.1 mi	214 ft	N41.88001 W87.62936
33	Get on S Dearborn St and drive north	2.1 mi	10 ft	N41.88001 W87.62939
34	TR3-14	2.3 mi	0.3 mi	N41.88392 W87.62940
35	Get on N Dearborn St and drive north	2.3 mi	12 ft	N41.88392 W87.62944
36	Turn right onto W Illinois St	2.8 mi	0.5 mi	N41.89083 W87.62961
37	TR3-15	2.8 mi	72 ft	N41.89083 W87.62936

IV. **<u>Outdoor Test Case (Deep Forest)</u>**

This test case assumes that all trees in this area are fully in leaf.

Location: Cook County Forest Preserve's *Swallow Cliffs Woods*
Palos Park, IL 60464

A. Deep Forest Test Route Map Image



*Note: Map image and directions sourced from Backpacker / Trimble Outdoors:
http://bp2.trimbleoutdoors.com/ViewTrip.aspx?tripId=23837

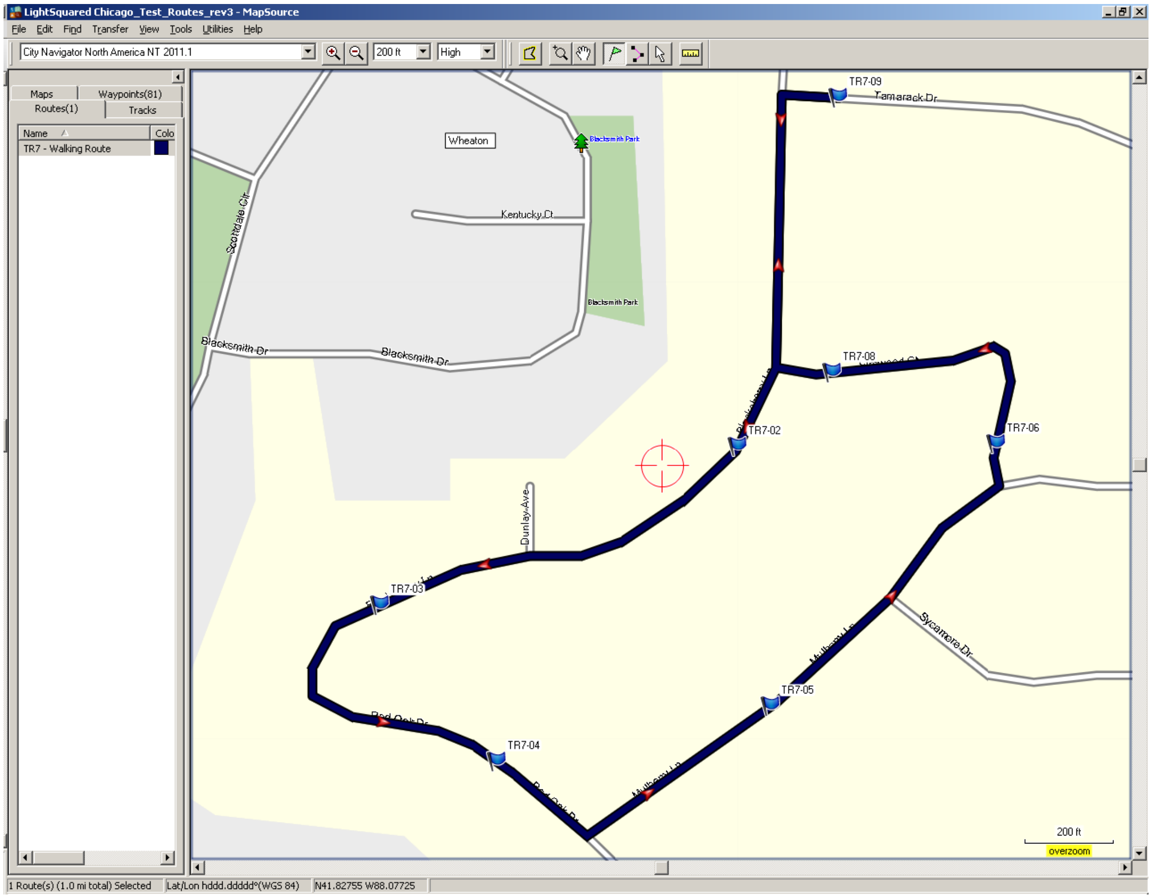
B. Deep Forest Test Route Walking Directions

Maneuver	Coordinates	
Start: Take R onto Brown Trail from lot	N41.674030	W87.860046
Swing Right @ 3-way and descend through first bog	N41.674011	W87.862587
Stay left on footpath; bear right into ravine, then follow gulch left.	N41.678280	W87.862793
Turn left at top of ravine; loop around on Yellow-blazed trail back to Swallow Cliffs	N41.677109	W87.869232
Zigzag along cliffs and bear right for descent to Teason's Woods	N41.678989	W87.872467
Turn right then go uphill	N41.683651	W87.873970
Crest knoll and take left and meander along cliffs	N41.682621	W87.878731
Left following yellow blazes	N41.676952	W87.887070
Reach ridge crest and take left at Y to skirt shoreline of Horsetail Lake	N41.672871	W87.881516
Stay left on yellow trail	N41.672173	W87.869133
Left at Y onto Brown Trail for .2 mi. to close loop	N41.673218	W87.866547

V. <u>Fitness Test Case (Arm Swing Environment)</u>

This test case assumes that all trees in this area are fully in leaf.

A. Arm Swing Test Route Map Image



B. Arm Swing Test Route Jogging Directions

	Maneuver / Waypoint	Cumulative Distance	Leg Distance	Coordinates
1	TR7-01	0 ft		N41.82789 W88.07426
2	Get on Tamarack Dr and drive west	0 ft	0 ft	N41.82789 W88.07426
3	Turn left onto Blackcherry Ln	116 ft	116 ft	N41.82791 W88.07469
4	TR7-02	0.2 mi	0.2 mi	N41.82575 W88.07502
5	Get on Blackcherry Ln and drive southwest	0.2 mi	0 ft	N41.82575 W88.07502
6	TR7-03	0.3 mi	0.2 mi	N41.82477 W88.07770
7	Get on Blackcherry Ln and drive southwest	0.3 mi	0 ft	N41.82477 W88.07770
8	Turn left onto Red Oak Dr	0.4 mi	270 ft	N41.82422 W88.07821
9	TR7-04	0.5 mi	411 ft	N41.82382 W88.07683
10	Get on Red Oak Dr and drive southeast	0.5 mi	0 ft	N41.82382 W88.07683
11	Turn left onto Mulberry Ln	0.5 mi	248 ft	N41.82336 W88.07615
12	TR7-05	0.6 mi	473 ft	N41.82415 W88.07477
13	Get on Mulberry Ln and drive northeast	0.6 mi	0 ft	N41.82415 W88.07477
14	Turn left onto Elmwood Ct	0.7 mi	0.1 mi	N41.82551 W88.07306
15	TR7-06	0.7 mi	96 ft	N41.82577 W88.07308
16	Get on Elmwood Ct and drive northwest	0.7 mi	0 ft	N41.82577 W88.07308
17	TR7-08	0.9 mi	0.1 mi	N41.82621 W88.07431
18	Get on Elmwood Ct and drive west	0.9 mi	0 ft	N41.82621 W88.07431
19	Turn right onto Blackcherry Ln	0.9 mi	116 ft	N41.82624 W88.07473
20	Turn right onto Tamarack Dr	1.0 mi	0.1 mi	N41.82791 W88.07469
21	TR7-09	1.0 mi	116 ft	N41.82789 W88.07426

Log File Format for Testing V1.0

I. Introduction

In order to simplify the processing to test results, a common log file is proposed. This log file is a simple comma delimited text file that will be very easy for test lab to import into any data processing tool they choose, such as Excel or MATLAB .

A note about time: Time is specified in the table below as GPS time. Currently, there is a 15 second offset between GPS time and UTC time (UTC leads GPS by 15 seconds). Due to issues with devices accurately reporting UTC (the number of leap seconds has changed over the years), an unambiguous time base is GPS time, which is consistent between all units.

II. File Format

Column Number (Letter)	Quantity	Format	Example
1 (A)	Year	xxxx	2011
2 (B)	Month	xx (leading zero optional)	05
3 (C)	Day(GPS Time, no time zone offset)	xx (leading zero optional)	02
4 (D)	Hour (GPS Time, no time zone offset)	xx (24 hour format)	14
5 (E)	Minute (GPS Time, no leap second offset)	xx	27
6 (F)	Second (GPS time, no leap second offset)	xx	59
7 (G)	Fix Indicator 0 – No fix 1 – 2D Fix 2 – 3D Fix 3 – 2D Diff. Fix 4 – 3D Diff. Fix	x	1
8 (H)	Latitude (WGS-84), decimal degrees Blank if no fix	±dd.ddddddd leading zero optional	38.1234567
9 (I)	Longitude (WGS-84), decimal degrees Western hemisphere negative Blank if no fix	±ddd.ddddddd leading zeros optional	-95.1234567
10	Height Above Ellipsoid (WGS-84), m	±xxxxx.xx	325.12

(J)	Blank if no fix	leading zeros optional	
11 (K)	East Velocity, m/s Blank if no fix	±xxxxx.xx leading zeros optional	-23.12
12 (L)	North Velocity, m/s Blank if no fix	±xxxxx.xx leading zeros optional	16.12
13 (M)	Up Velocity, m/s Positive up Blank if no fix	±xxxxx.xx leading zeros optional	-2.46
14 (N)	C/N_0, PRN1 0.00 if PRN is not being tracked	xx.xx	39.83
15 (O)	C/N_0, PRN2 0.00 if PRN is not being tracked	xx.xx	41.25
More columns to enumerate all 32 GPS PRNs			
46 (AS)	C/N_0, PRN32 0.00 if PRN is not being tracked	xx.xx	41.25
47 (AT)	C/N_0, SVID33 (PRN 120) For WAAS 0.00 if PRN is not being tracked	xx.xx	38.71
More columns if needed to enumerate additional WAAS satellites			

LightSquared Transmitter Simulator Test Bed Limits (provided by Alcatel-Lucent / Bell Labs)

I. Introduction

The following tables have been provided by Bell Labs to show the limits of the test bed with respect to interferer transmit power and simulated distance from an actual LightSquared transmit antenna. Any deviations from this setup and calibration shall be noted in the final test report.

Test Bed Limits – LightSquared Downlink Simulator

Bell Labs LightSquared GPS Test Bed Calibration

C.Meyer 11-May-11

Maximum LightSquared TX Power:	**62**	dBm EIRP	**(downlink)**
Test Antenna Separation:	**3**	Meter	
Antenna Front-Back Isolation:	**30**	dB	
Radiating Antenna Gain:	**8.8**	dBi	
Free space loss frequency:	**1550.2**	MHz	
Test Bed Power Meter Offset:	**20**	dB	

Raw Pwr Mtr dBm	LTE TX Power dBm	LTE TX EIRP dBi	Propgation Loss dB	Power at device dBm	Power diff dB	Equivalent Boresight Distance Meters	Equivalent Boresight Distance Feet	Equivalent off-lobe Distance Meters	Notes
-25.0	-5	3.8	45.8	-42.0	104.0	2438	8000	77.1	1
-24.0	-4	4.8	45.8	-41.0	103.0	2173	7130	68.7	
-23.0	-3	5.8	45.8	-40.0	102.0	1937	6355	61.3	
-22.0	-2	6.8	45.8	-39.0	101.0	1726	5664	54.6	
-21.0	-1	7.8	45.8	-38.0	100.0	1539	5048	48.7	
-20.0	0	8.8	45.8	-37.0	99.0	1371	4499	43.4	
-19.0	1	9.8	45.8	-36.0	98.0	1222	4010	38.6	
-18.0	2	10.8	45.8	-35.0	97.0	1089	3574	34.4	
-17.0	3	11.8	45.8	-34.0	96.0	971	3185	30.7	
-16.0	4	12.8	45.8	-33.0	95.0	865	2839	27.4	
-15.0	5	13.8	45.8	-32.0	94.0	771	2530	24.4	
-14.0	6	14.8	45.8	-31.0	93.0	687	2255	21.7	
-13.0	7	15.8	45.8	-30.0	92.0	613	2010	19.4	
-12.0	8	16.8	45.8	-29.0	91.0	546	1791	17.3	
-11.0	9	17.8	45.8	-28.0	90.0	487	1596	15.4	
-10.0	10	18.8	45.8	-27.0	89.0	434	1423	13.7	
-9.0	11	19.8	45.8	-26.0	88.0	386	1268	12.2	
-8.0	12	20.8	45.8	-25.0	87.0	344	1130	10.9	
-7.0	13	21.8	45.8	-24.0	86.0	307	1007	9.7	
-6.0	14	22.8	45.8	-23.0	85.0	274	898	8.7	
-5.0	15	23.8	45.8	-22.0	84.0	244	800	7.7	
-4.0	16	24.8	45.8	-21.0	83.0	217	713	6.9	
-3.0	17	25.8	45.8	-20.0	82.0	194	635	6.1	
-2.0	18	26.8	45.8	-19.0	81.0	173	566	5.5	
-1.0	19	27.8	45.8	-18.0	80.0	154	505	4.9	
0.0	20	28.8	45.8	-17.0	79.0	137	450	4.3	
1.0	21	29.8	45.8	-16.0	78.0	122	401	3.9	
2.0	22	30.8	45.8	-15.0	77.0	109	357	3.4	
3.0	23	31.8	45.8	-14.0	76.0	97	318	3.1	
4.0	24	32.8	45.8	-13.0	75.0	87	284	2.7	
5.0	25	33.8	45.8	-12.0	74.0	77	253	2.4	
6.0	26	34.8	45.8	-11.0	73.0	69	225	2.2	
7.0	27	35.8	45.8	-10.0	72.0	61	201	1.9	
8.0	28	36.8	45.8	-9.0	71.0	55	179	1.7	
9.0	29	37.8	45.8	-8.0	70.0	49	160	1.5	
10.0	30	38.8	45.8	-7.0	69.0	43	142	1.4	

II. Test Bed Limits – LightSquared Uplink Simulator

Bell Labs LightSquared GPS Test Bed Calibration

C.Meyer 11-May-11

Maximum LightSquared TX Power:	**23**	dBm EIRP	**(uplink)**
Test Antenna Separation:	**3**	Meter	
Antenna Front-Back Isolation:	**n/a**	dB	
Radiating Antenna Gain:	**8.8**	dBi	
Free space loss frequency:	**1632.5**	MHz	
Test Bed Power Meter Offset:	**20**	dB	

Raw Pwr Mtr dBm	LTE TX Power dBm	LTE TX EIRP dBi	Propgation Loss dB	Power at device dBm	Power diff dB	Equivalent Distance Meters	Equivalent Distance Feet	Notes
-25	-5	3.8	46.2	-42.4	65.4	27	90	1
-24	-4	4.8	46.2	-41.4	64.4	24	80	
-23	-3	5.8	46.2	-40.4	63.4	22	71	
-22	-2	6.8	46.2	-39.4	62.4	19	64	
-21	-1	7.8	46.2	-38.4	61.4	17	57	
-20	0	8.8	46.2	-37.4	60.4	15	50	
-19	1	9.8	46.2	-36.4	59.4	14	45	
-18	2	10.8	46.2	-35.4	58.4	12	40	
-17	3	11.8	46.2	-34.4	57.4	11	36	
-16	4	12.8	46.2	-33.4	56.4	10	32	
-15	5	13.8	46.2	-32.4	55.4	9	28	
-14	6	14.8	46.2	-31.4	54.4	8	25	
-13	7	15.8	46.2	-30.4	53.4	7	23	
-12	8	16.8	46.2	-29.4	52.4	6	20	
-11	9	17.8	46.2	-28.4	51.4	5.5	18	
-10	10	18.8	46.2	-27.4	50.4	4.9	16	
-9	11	19.8	46.2	-26.4	49.4	4.3	14	
-8	12	20.8	46.2	-25.4	48.4	3.9	13	
-7	13	21.8	46.2	-24.4	47.4	3.4	11	
-6	14	22.8	46.2	-23.4	46.4	3.1	10	
-5	15	23.8	46.2	-22.4	45.4	2.7	9.0	
-4	16	24.8	46.2	-21.4	44.4	2.4	8.0	
-3	17	25.8	46.2	-20.4	43.4	2.2	7.1	
-2	18	26.8	46.2	-19.4	42.4	1.9	6.4	
-1	19	27.8	46.2	-18.4	41.4	1.7	5.7	
0	20	28.8	46.2	-17.4	40.4	1.5	5.0	
1	21	29.8	46.2	-16.4	39.4	1.4	4.5	
2	22	30.8	46.2	-15.4	38.4	1.2	4.0	
3	23	31.8	46.2	-14.4	37.4	1.1	3.6	
4	24	32.8	46.2	-13.4	36.4	1.0	3.2	
5	25	33.8	46.2	-12.4	35.4	0.9	2.8	
6	26	34.8	46.2	-11.4	34.4	0.8	2.5	
7	27	35.8	46.2	-10.4	33.4	0.7	2.3	
8	28	36.8	46.2	-9.4	32.4	0.6	2.0	
9	29	37.8	46.2	-8.4	31.4	0.55	1.8	
10	30	38.8	46.2	-7.4	30.4	0.49	1.6	

Appendix F

HIGH PRECISION AND TIMING RECEIVER LIGHTSQUARED L-BAND LTE RFI TEST PLAN

REVISION HISTORY

REV	Date	Editor	DESCRIPTION
B	3/22/2011	P. Fenton	Initial Draft
C	3/25/2011	P. Fenton	Incorporating initial feedback
D	4/4/2011	P. Galyean	Incorporating result of first Sub-Team meeting
E	4/6/11	P. Galyean	Incorporating results of second Sub-Team meeting
F	4/7/11	P. Fenton	Incorporating homework
G	4/7/11	P. Fenton	Incorporating results of second Timing Team meeting
H	4/7/11	P. Galyean	Incorporating homework
I	4/8/11	P. Galyean	Revisions per Sub-Team meetings
J	4/18/11	P. Galyean	Revisions per Sub-Team meetings
K	5/5/11	P. Galyean	Revisions per Spirent automation discussions
L	5/6/11	P. Galyean	Revisions per Spirent automation discussions
M	5/7/11	P. Galyean	Fix art problem

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Purpose

This document outlines the test setup and test procedure to evaluate Timing and High Precision GNSS receiver performance when the LightSquared L-band LTE signals are present.

Basic Assumptions

The following assumptions control certain aspects of this Test Plan.

1) All testing must be completed by 5/31/2011.
2) Testing must be controlled and executed by a laboratory independent of LightSquared and of USGIC and its members.
3) All testing must be transparent, i.e., the testing can be observed by the concerned parties.
4) The test data must be recorded and available to all appropriate parties, in accordance with overall TWG agreements. The test results must be made publicly available in a consolidated form with coding that does not disclose the identity of individual receivers.
5) We expect the processing of the raw data into performance data to be done by the manufacturers, with LightSquared as observers if LightSquared desires.
6) Anechoic chamber testing must be done, and open air testing will be done if possible.
7) The selection of receivers to be tested must represent the installed base as well as current production receivers, and must represent critical applications.
8) It will be necessary to test multiple receivers at one time.
9) Testing over temperature is not required, and can be at ambient temperature.
10) It is necessary to characterize and record the effects on receiver performance as observed by users of the receivers as well as the internal metrics of the receivers.
11) Testing of LightSquared handsets (or functionally similar replicas) is to be done, but the emphasis will be on testing interference from LightSquared base stations.
12) Testing of receivers must range broadly over the population, and not be restricted to "obvious" receivers.
13) Glonass will not be radiated in the chamber tests.
14) We don't plan to deal with process variations for a given receiver type. There are enough receivers of various types that having an abnormal receiver won't affect the conclusions, and will probably be detected in any event.
15) Testing of a handset in the chamber at the same time as the base station testing will be done by using three generators.

Test Scenarios

High Precision Receivers – Anechoic Chamber Testing

High precision receivers have multiple modes, depending on the particular receiver, which must be tested. These include:

1) Autonomous (stand alone)
2) RTK
3) Augmentation (WAAS, OmniSTAR, StarFire)

For RTK testing, there are four sub-cases to consider:

1) The Rover and Base both experience interference.
2) The Rover experiences interference and the Base does not.
3) The Base experiences interference and the Rover does not.
4) The Rover and Base both do not experience interference (this is for comparison to the interference cases).

Timing Receivers – Anechoic Chamber Testing

Timing receivers have multiple modes, depending on the particular receiver, which must be tested. These include:

1) Autonomous (stand alone)
2) WAAS augmentation

High Precision Receivers – Field Testing

TBD

Timing Receivers – Field Testing

TBD

Anechoic Chamber Testing

Test Structure Requirements

To permit testing that meets the requirements of Section 0, the test structure must have the following characteristics:

1) An anechoic chamber of sufficient size to permit the testing of multiple receivers simultaneously must be available. To avoid geometric effects that could result from having transmitting and receiving antennas too close, at least 5 meters are needed between them.
2) A test structure must be constructed that can hold multiple receivers for the test. All receivers are to be tested simultaneously.

3) The signals generated by the LightSquared generators must replicate the signals that will be used in field operations.
4) Calibration of the transmitters and anechoic chamber must be done to ensure the transmitted signals are well characterized and understood. There must be sufficient high quality instrumentation to ensure that the measurements taken are valid.
5) Each high precision manufacturer may have one receiver outside the chamber which will receive the GPS simulator signal to characterize the differences in performance between units subject to LightSquared signals and those not subject to it. This will also enable the RTK test cases to be performed.
6) It must be possible to vary the LightSquared signal power, to generate both the 5 MHz and 10 MHz LightSquared signals, and to operate the two generators simultaneously.
7) It must be possible to generate GPS L1 and L2 satellite signals with varying number of satellites and signal powers. The only GPS signals to be generated are L1 C/A, L1P, and L2P.
8) It must be possible to generate the StarFire and OmniSTAR augmentation signals for those receivers which use them.
9) There must be sufficient isolation and attenuation to ensure that signals from inside the chamber do not feed back or affect the measuring instruments or receivers outside the chamber.
10) The frequency stability of the GNSS Signal Generator must be of higher quality than the oscillators in the Timing UUTs.
11) Each manufacturer should be responsible for setting up a LAN or other data communications structure to enable its receivers to provide data to its logging/control PCs.

Figure 5 below illustrates the test setup.

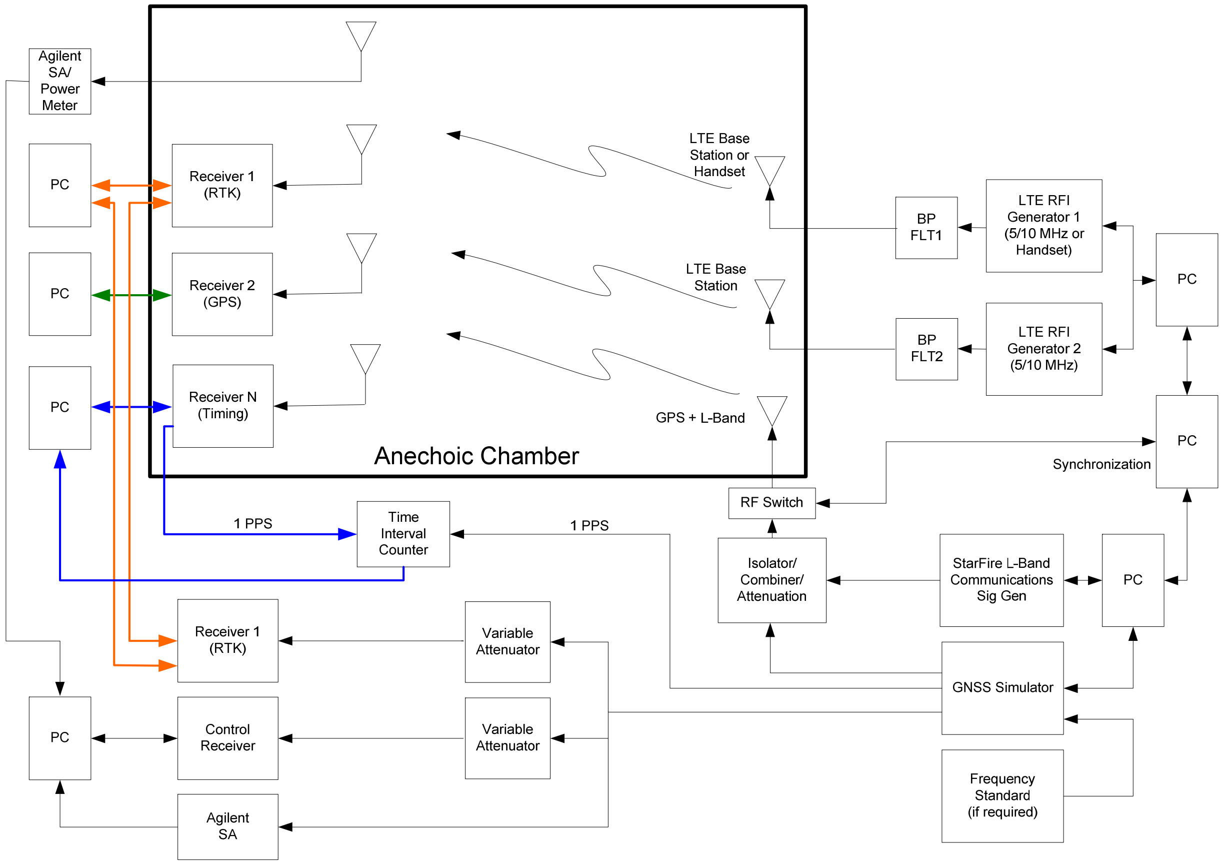

Figure 5 Test Setup

Physical Test Structure

The anechoic chamber tests will be conducted at the NAVAIR facility in Maryland. The chamber measures 40 ft x 40 ft x 100 ft.

There are two small doors into the chamber, and one large access door. The normal entrance leads into a ground floor lab, and it has a door into the chamber. This door is at the transmit end of the chamber. There is an elevated floor for personnel access to the chamber and which can be used for cabling. The second small door is at the receive end of the chamber and exits outdoors. The large access door is at the receive end of the chamber.

The transmit window is half way up the 40 foot wall (centered 20 ft from the floor and the sides). The opening is about 3 ft x 3 ft. The GPS/StarFire/OmniSTAR antenna will be mounted through the transmit window (there is an upstairs lab behind the transmit window). The LTE transmitters will be mounted on poles at the rear of the chamber at the same elevation as the GPS antenna.

The antennas (and receivers with integral antennas) will be mounted in a grid framework to give them a boresight arrangement with the transmitters. This will require a wood structure that will be built outside and assembled inside the chamber. There is a hoist inside the chamber that can be used to erect it inside the chamber. There is a Hi-Reach that can be used to help mount the antennas or receivers after the grid is erected. See Figure 6 and Figure 7.

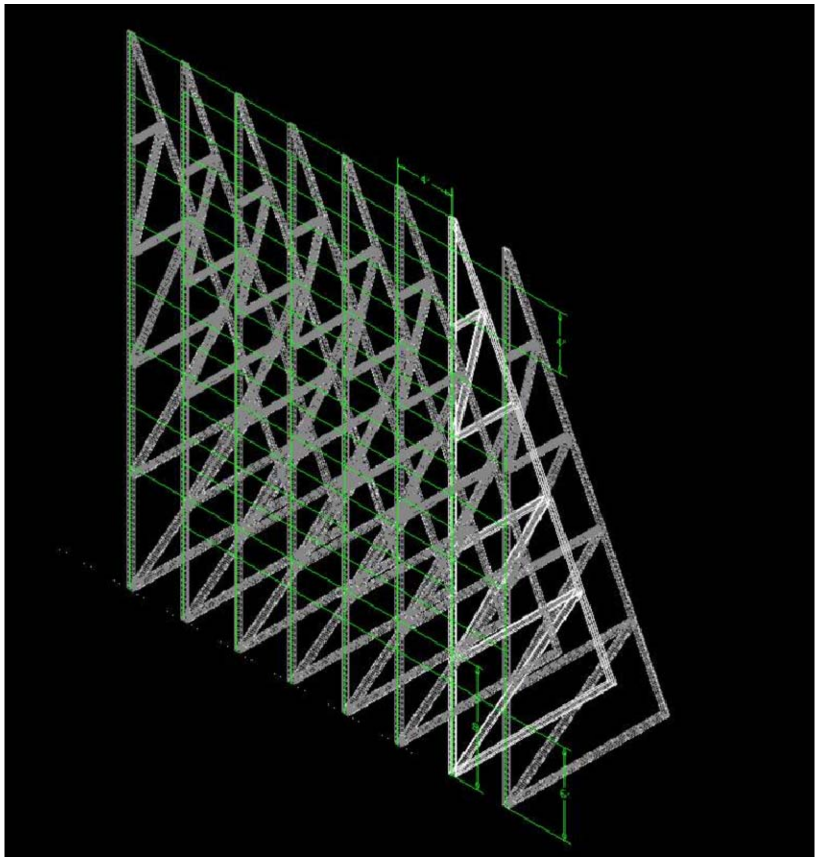

Figure 6 Antenna/Receiver Grid-1

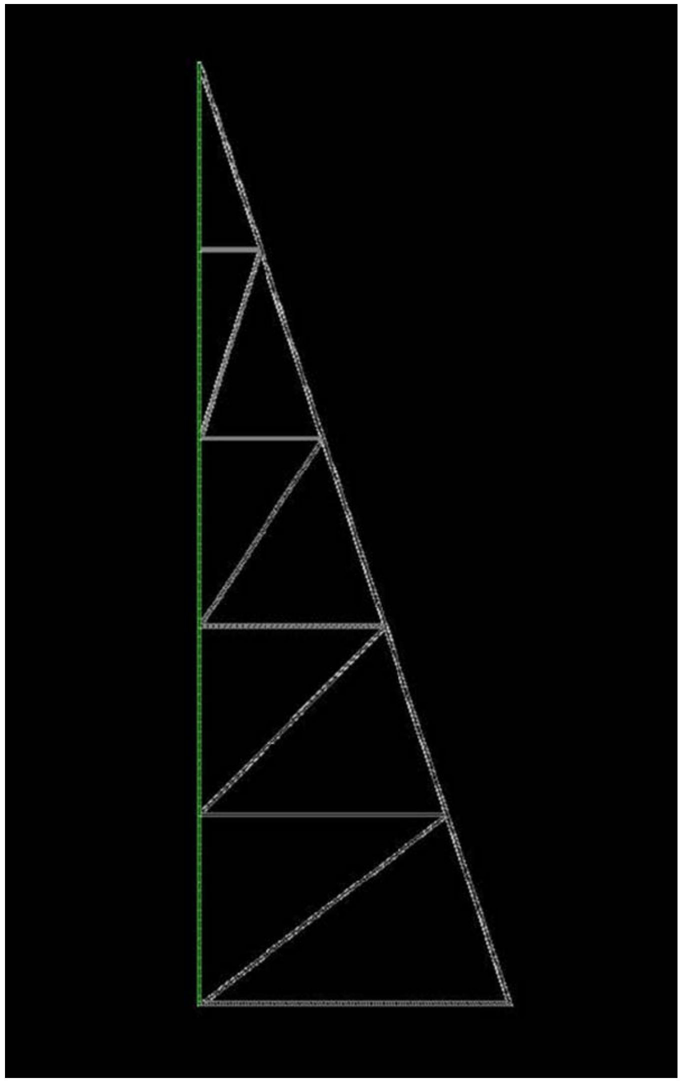

Figure 7 Antenna/Receiver Grid-2

The grid will be constructed so that the receivers can be placed at the bottom of it and sheltered with absorber.

The logging laptops are to be placed in the labs at the transmit end of the chamber.

LightSquared LTE Signals

The LightSquared LTE base station signals will be in the 1525 MHz – 1559 MHz band. The LightSquared handset signals will be in the 1626.5 MHz – 1660.5 MHz band. LightSquared will implement their system in three phases:

- Phase 0: One 5 MHz channel: 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel ($F5_{High}$)
- Phase 1A: Two 5 MHz channels: 1526.3 MHz - 1531.3 MHz ($F5_{Low}$) and 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel

- Phase 2: Two 10 MHz channels: 1526 MHz -1536 MHz ($F10_{Low}$) and 1545.2 MHz - 1555.2 MHz ($F10_{High}$), 62 dBm EIRP per 10 MHz channel

LightSquared plans in all three phases to operate base stations at least 4 MHz away from the GPS band at 1559 MHz.

When both the Low and High LTE base station signals are used, they will be radiated with orthogonal polarizations.

In one test, a simulated handset will be used. The frequency for the handset (HS) will be 1627.5 – 1637.5 MHz. The maximum power from the handset is intended to simulate the effect of having a handset 1 meter from a GPS antenna. The EIRP of the handset is +23 dBm. Allowing for 37 dB path loss, the power at the GPS antenna should be -14 dBm.

The following seven LTE base station and handset carrier frequency configurations will be used for the interference testing:

- $F5_{Low}$
- $F5_{High}$
- $F5_{High}$ + $F5_{Low}$
- $F10_{Low}$
- $F10_{High}$
- $F10_{High}$ + $F10_{Low}$
- HS

These frequencies are chosen to have the potential to create 3^{rd} order intermod products that may fall within the GPS L1 band.

Setup and Calibration of LightSquared LTE Signals

- Since the actual base station antenna cannot be used, a measured, calibrated field strength will be generated using a vertical, linear polarized horn antenna with a known gain. This antenna will be directed with the peak gain pointed at the region where the UUTs will be tested.
- The LTE signal will be pointed directly at the boresight of the UUTs.
- The distance in meters between the face of the horn antenna and the UUTs will be measured and recorded.
- Mount both the LTE horns and the GPS simulator transmit antenna in place with no UUT equipments in place.
- Turn the LTE transmitter on with the attenuator at a known setting and measure the field strength at the locations where the UUTs will be placed.
- Vary the attenuator through at least three settings across the range of LightSquared power and record the field strength to calibrate the attenuator(s), or calibrate the attenuator(s) using a network analyzer.

Note: The equivalent outdoor separation which will have a similar effect can be determined (and bounded) using a propagation model. Some possible choices are:

- Free space model: $(1/R^2)$
- $R_{outdoors}=R_{chamber}*sqrt(Gain_{LTE\ outdoor\ antenna}/Gain_{Tx\ Horn\ used\ in\ test})$
- Urban environments: $(1/R^{3.5})$
- Walfisch-Ikegami model

The LTE signal will be pointed directly at the boresight of the UUT, while a typical use case will be at a lower elevation. This will likely produce some rolloff and will reduce the equivalent outdoor separation.

Setup and Calibration of GNSS Signals

- The GNSS signal generator shall be locked to a high quality external frequency source.
- The simulator used to generate the GNSS signals will have internal noise that permits the C/N_0 ratios to be set independent of the actual output power. This can be maintained even when using external amplifiers, provided the additional amplifier's noise power is well below the simulator output power.
- The GPS radiating antenna must be right hand circularly polarized and be pointed at the boresight (top or zenith) of the UUTs.
- The UUT antenna gain characteristics should be entered into the simulator, or an approximation, to correct for elevation variations of the constellation.
- Set the peak C/N_0 to 47 dB-Hz.
- Using a representative UUT and antenna and with the LTE on, record the C/N_0 of the peak satellite and reduce the gain of the GNSS signal until the UUT reports a decrease in C/N_0 of 3 dB. Now the noise in the environment and the simulator are equal and any additional noise will be detected.
- This level and setting must be recorded and used throughout the testing as the reference level.

Setup and Calibration of the Timing Equipment

- Some Timing UUTs will have an associated Time Interval Counter (TIC).
- The primary 1PPS control signal shall be provided by the GNSS Signal Generator.
- If required by the TIC, a stable frequency source can be provided by the GNSS frequency reference.
- Measure and record the steady-state time interval before the LTE signals are applied.
- Use the clean steady-state measurement above as the "truth" value during the subsequent LTE emissions tests.

Data Recording

To the extent possible, the following GPS, WAAS, and augmentation internal performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Pseudorange
- Carrier Phase
- Doppler
- C/N_0
- Optional Parameters (UUT specific)
    - Carrier tracking variance
    - Pseudorange tracking variance
    - Lock Times
    - Lock Breaks
    - Signal Quality
    - WAAS Bit Error Rate
    - L band augmentation communications
        - Packet Error Rate
        - E_b/N_0

To the extent possible, the following GPS, WAAS, Timing, and augmentation external performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Position accuracy
    - GPS stand alone
    - GPS + Augmentation
    - GPS + WAAS
    - GPS + RTK
- Pseudorange accuracy
- Carrier phase accuracy
- Range Rate (Doppler) accuracy
- Mean Time between Cycle Slips
- Mean Time between Lock breaks
- Reacquisition time statistics (Hot Start)
- Acquisition time statistics (Warm and Cold Starts)

- RTK ambiguity resolution statistics
- 1PPS error as measured by the TIC (for timing receivers)
- Receiver Status including Holdover Mode flag (for timing receivers)

Test Automation

Spirent will be providing automation of the LTE generators and the Spirent simulator. There are constraints that apply to this automation:

1) Time from the Spirent GPS simulator will be used to coordinate all testing activities. Time must increase monotonically throughout the tests, but will not be synchronized to real world time.
2) The GPS scenarios in the Spirent simulator will use 24 satellites. The power from the satellites will be set to the minimums specified in ICD-GPS-200C. There will be 4 satellites in each of the 6 GPS planes, with spacing between satellites reasonably uniform.

   ICD-GPS-200C gives minimum power at 5 degrees elevation of -160 dBW for L1 C/A, -163 dBW for L1P, and -166 dBW for L2P. It shows power increases of up to 2 dB as elevation increases. The curves shown in Figure 6-1 in ICD-GPS-200C should be used for the satellites in this test plan.
3) The receive antenna model used in the Spirent simulator will be that from a standard Dorne and Margolin choke ring.
4) The assumed location of the receivers for the Spirent scenarios will be:
   - Latitude: 30° 15'
   - Longitude 76° 25'

Interference Tests

For each batch of receivers, five types of tests will be conducted:

- Tracking
- Reacquisition
- Tracking Sensitivity
- Acquisition

These are defined in the sections below. The power ranges for the base station tests and the handset test are different:

- Base station: -70 (MIN) dBm to +10 (MAX) dBm
- Handset: -94 (MIN) dBm to -14 (MAX) dBm

The terms MIN and MAX are used in the test description to refer to these power levels. These power levels assume input into a 0 dBi antenna at the center of the grid.

Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0.

1) Record the performance parameters for each UUT as defined in section 0, including C/N_0.
2) Set each LTE simulator employed for the selected configuration to an output power of MIN dBm (at the receivers).
   a) Record the performance parameters for each UUT and the LTE simulator power for 60 seconds.
   b) Increase the power of the LTE simulators output by 1 dB.
   c) Repeat steps 2a) and 2b) until the output power of the LTE simulators has reached MAX dBm.
3) Dwell at MAX dBm for two minutes.
4) Set each LTE simulator employed for the selected configuration to an output power of MAX dBm.
   a) Record the performance parameters and LTE simulator power for 60 seconds.
   b) Decrease the power of the LTE simulator output by 1 dB.
   c) Repeat steps 4a) and 4b) until the LTE simulator power is set to MIN dBm.
5) From the data collected during 2) - 4):
   a) Each manufacturer will identify two base station configurations as candidates for all subsequent tests.
   b) The Test Coordinator will identify the minimum set of base station configurations that covers all of the candidates provided in 5a). All subsequent tests will be conducted using that reduced set. For time estimating, it will be assumed that four base station configurations will suffice.

Estimated Test Time for Tracking Test Procedure:

1) Seven base station configurations from MIN dBm to MAX dBm at 60 seconds/dB: 7 * 60 * (70 + 10) +7*120 = 34,440 seconds = 9.6 hours.
2) Seven base station configurations from MAX dBm to MIN dBm at 60 seconds/dB: 7 * 60 * (70 + 10) 7*120 = 34,440 seconds = 9.6 hours.
3) Total test time: 9.6 + 9.6 = 19.2 hours.

Reacquisition Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0 5b, the following procedure should be performed with the GPS simulator set up as described in section 0.

1) With LTE power off, collect 15 minutes of tracking performance parameters.
2) For each of the LTE base station configurations:
   a) Set the LTE simulators to a power output of power of MIN dBm (at the receivers).
   b) Record tracking parameters for 30 seconds.
   c) Reduce the GPS signal power to zero for 10 seconds by disconnecting GPS simulator power to the radiating antenna through the use of a RF switch.
   d) Resume GPS signal level to nominal value indicated in section 0.
   e) Repeat 2b) through 2d) for 25 iterations.
   f) Increase LTE power by 5 dB.
   g) Repeat steps 2a) through 2f) until the LTE output power is set to MAX dBm.

Estimated Test Time for Reacquisition Test Procedure

1) Four LTE base station configurations, 17 signal power cases, 25 iterations at 40 seconds/iteration: 900 + 4 * 40 * 5 * 25 = 68,900 seconds = 19.2 hours.

Sensitivity Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0 5b), the following procedure should be performed with the GPS simulator set up as described in section 0. The Spirent simulator should be configured for a uniform antenna pattern, i.e., all GPS satellite signals should be set to the same level as specified in section 0.

1) With LTE simulator power off and GPS at nominal signal levels specified in section 0, collect 15 minutes of tracking performance parameters.
2) For each LTE power level from MIN dBm to MAX dBm in 5 dB steps:
   a) Set the power level of the LTE simulators to the specified power.
   b) Continuously record performance data during 2).
   c) Reduce GPS simulator power at a rate of 1 dB/min for 15 minutes.
   d) Set the GPS simulator back to nominal signal level.
   e) Turn the LTE simulator power off.

f) Wait 2 minutes to allow all UUTs to stabilize.

Estimated Test Time for Sensitivity Tracking Test Procedure:

1) Four base station configurations, five LTE power levels, 30 minute iteration for two iterations: 900 + 4 * 17 * 1020 = 70,260 = 19.5 hours.

Acquisition Test Procedure

This test case will be done from a “warm” start condition. The intent is that a normal acquisition processes be conducted between restarts, one that results from having ephemeris and position, but not precise GPS time (bit sync unknown).

For each of the LTE base station configurations specified in section 0 5b), the following procedure should be performed with the GPS simulator set up as described in section 0.

1) Power on all UUTs and record performance data for 5 minutes.
2) For each LTE power level from MIN dBm to MAX dBm in 10 dB steps:
   a) Record performance data for 15 minutes.
   b) During each 15 minute test, each manufacturer should force restarts on their equipment at least every 3 minutes. If proper operation can be established in less time, then restarts can be initiated more often (this is at the manufacturers option). A minimum of 4 restarts should be initiated at each power level.

Estimated Test Time for Acquisition Test Procedure

1) Four base station configurations, nine power levels, 15 minutes per power level: 4* 900 * 9 = 33,000 seconds = 9.2 hours.

Total Test Time

Tracking =	19.2 hours
Reacquisition =	19.2 hours
Tracking Sensitivity =	19.5 hours
Acquisition =	9.2 hours
Total =	67.1 hours

Expected Processing Results

It is expected that each manufacturer will need to use its proprietary software to process the recorded data. The data needs then to be presented in a uniform structure that is amenable to evaluation and aggregation.

Template – High Precision Receivers

TBD.

Template – Timing Receivers

TBD.

References

TBD.

Field Testing

TBD.

Appendix G

LightSquared Live-Sky Test Environment

Field Test Methodology

The test plan described here characterizes the performance of GPS receivers (the devices under test, or DUT's) in the presence of L-band base station downlink signals in an outdoor environment with live GPS satellite signals. Production base station transmitter subsystems (including production PA's, filters and other RF components) and antennas will be used. The base station installation will be representative of actual deployment, including a 2^0 electrical antenna downtilt. The antennas will comprise 45^0 cross-polarized elements fed by separate PA's emitting MIMO signals. As per LightSquared's initial deployment plan, the base station will emit L-band signals at the full 32dBW/carrier (29 dBW/carrier/MIMO branch). 100% loading will be emulated using dummy user data.

The planned base station power levels and spectrum occupancies are shown in Figure 8; details of the test sites are provided in Table 4 and a high level diagram of the test site locations is show in Figure 9.

For the planned tests, owing to the limited time available, only the Phase-1 configuration will be tested.[10] This will comprise two 5 MHz carriers, each at 32 dBW, in each of 3 sectors. Some limited tests will also be performed with the two carriers individually.

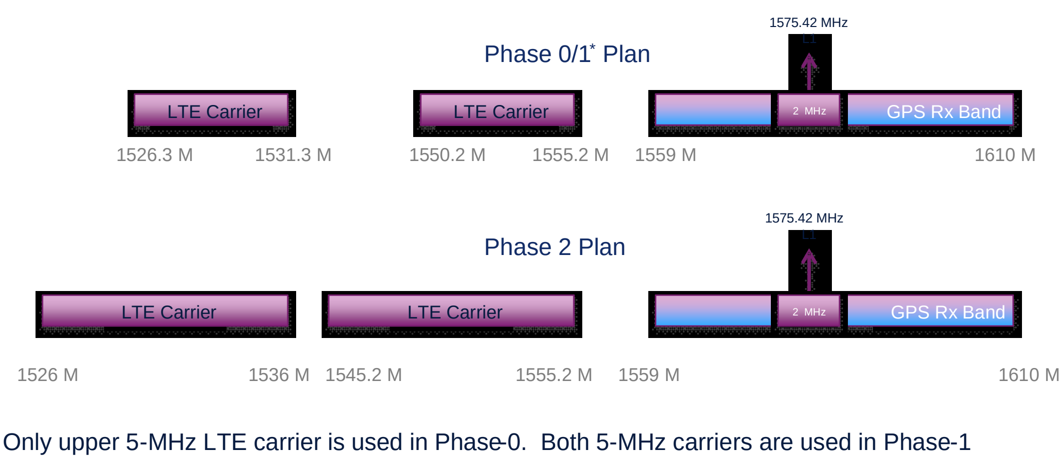

Figure 8: LightSquared Downlink LTE Band 24 and GPS Band (EIRP per carrier: 32 dBW)

[10] Phase-1 is considered to be the worst of all deployment phases for GPS receiver vulnerability as it has the (a) the highest inband power spectral density and (b) the highest power spectral density nearest to the RNSS band. The two individual 5 MHz channels will be tested separately as this test can show the vulnerability of a given device to 3rd order IM; this may be an indicator of the extent of preselector filtering across Band 24.

LightSquared Site ID	Latitude	Longitude	Antenna Height AGL (ft)	Number of Sectors	Azimuths (degrees)	City
LVGS0053-C1	35.9697	-114.8681	60	2	30, 270	Rural
LVGS0068-C1	36.1245	-115.2244	55	3	0, 120 ,240	Suburban
LVGS0160-C1	36.127	-115.189	50	3	0, 120, 240	Urban
LVGS0217-C1	36.1065	-115.1705	235	2	0, 240	Dense Urban

Table 4: Test Site Details

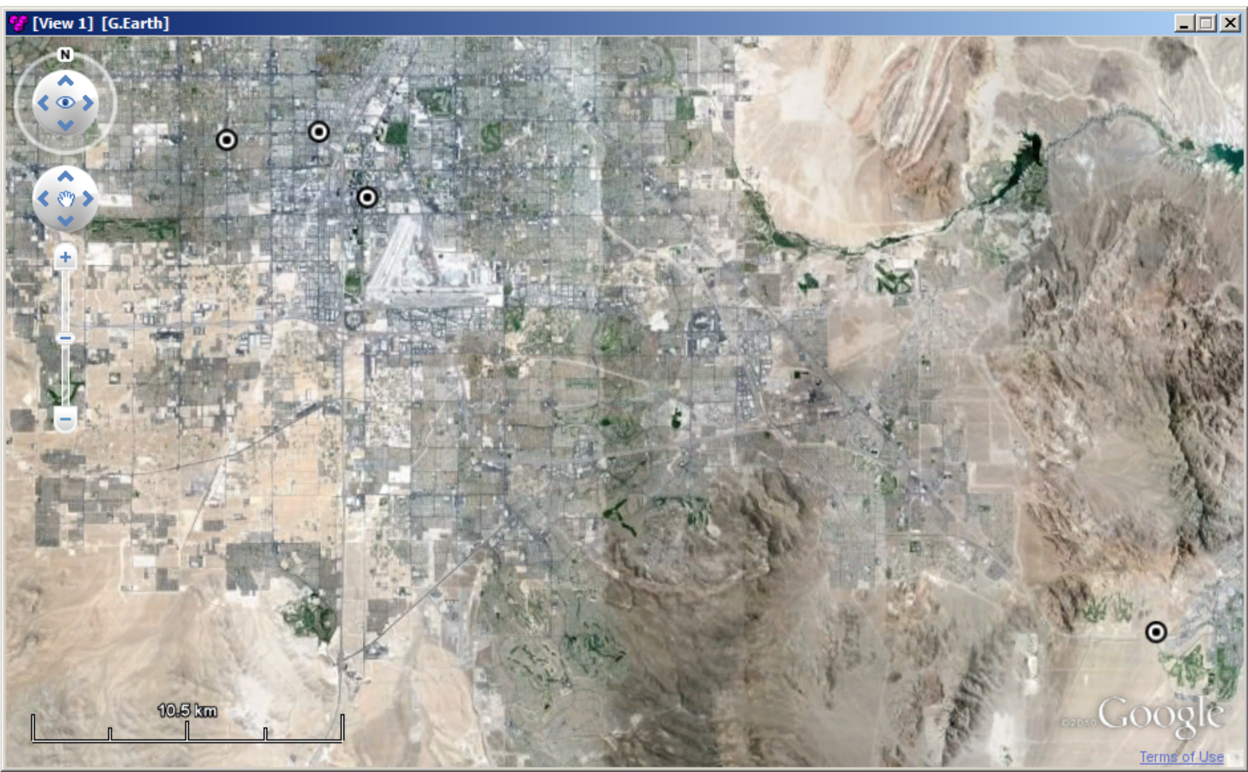

Figure 9: Test Site Location Map

Cell Site Link Budget Details

Antenna TX Power Budget Site 68 (All Sectors)		
RRH Power	43	dBm
LDF4 1/2" Coax Loss	-3.3	dB
Antenna Gain dBi	16.8	dBi
EIRP	56.5	dBm
Total EIRP per sector with MIMO active	59.5*	dBm

Antenna TX Power Budget Site 160 (All Sectors)		
RRH Power	43	dBm
LDF4 1/2" Coax Loss	-3.5	dB
Antenna Gain dBi	16.8	dBi
EIRP	56.3	dBm
Total EIRP per sector with MIMO active	59.3*	dBm

Antenna TX Power Budget Site 53 (All Sectors)		
RRH Power	43	dBm
LDF4 1/2" Coax Loss	-3.5	dB
Antenna Gain dBi	16.8	dBi
EIRP	56.3	dBm
Total EIRP per sector with MIMO active	59.3*	dBm

Antenna TX Power Budget Site 217 (All Sectors)		
RRH Power	43	dBm
LDF4 1/2" Coax Loss	-3**	dB
Antenna Gain dBi	16.8	dBi
EIRP	56.8	dBm
Total EIRP per sector with MIMO active	59.8*	dBm

* Note 1: The eNodeB software does not support two carriers per sector until a future release. For two carrier tests, the eNodeB will require that each carrier be separately input to one of the two antenna ports and will result in the MIMO gain not being present. Thus total sector EIRPs will be down 3 dB from the table values for the two carrier tests.

** Note 2: For Site 217 the LDF Coax Loss has not been verified as of the revision of this document. A budgetary number of 3 dB was used and the nominal value for the actual measure value is not expected to be +/- 0.5 dB.

Las Vegas Live Sky LTE Signal Characteristics

The LightSquared eNodeB LTE test signal is per an ETSI standard definition. The eNodeBs in the Las Vegas Live Sky testing will use the E-UTRA Test Model 1.1 (E-TM1.1) as defined for the applicable 5 MHz channels. The specific of the channel characteristics can be found in the ETSI 3GPP Technical Specification 36.141 version 10.1.0. Release 10 under section 6.1.1.1. The physical channel parameters for a 5 MHz channel apply as detailed in Table 6.1.1.1-1 of the test model.